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COMPUTER SIMULATOR FOR A MOBILE TELEPHONE SYSTEM

NASA-LEWIS Research Center

Cleveland Ohio

April 21, 1982 - January 25, 1983

NASA Grant: NAG 3-277

Donald L. Schilling
Professor of Electrical Engineering
Principal Investigator

Chaim Ziegler
Assoc. Prof. of Computer Science
Co-Principal Investigator

COMMUNICATIONS SYSTEMS LABORATORY
DEPARTMENT OF ELECTRICL ENGINEERING

THE CITY COLLEGE OF
THE CITY UNIVERSITY of NEW YORK

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1. Introduction

This project is the result of a joint effort between the Department of Electrical Engineering at the City College, CUNY; and the Department of Computer & Information Science at the Brooklyn College, CUNY.

The goal of this project is to develop a software simulator to help NASA in the design of the LMSS. The simulator will be used to study the characteristics and implementation requirements of the LMSS's configuration with specifications as outlined by NASA.

This report represents progress made in implementing the simulator during the period 4/21/82 - 1/25/83.

2. The Present Simulator

The basic components of the present simulator were described previously in the first report (NASA Grant: NAG 3-119). However, previously, not all the components of the system were operational and only scenario 1 was implemented.

The current simulation now includes all the components, such as the interference sources, the S-band channels, the noise sources, the gateways, a revised master controller for the simulator, as well as other components which were recently completed.

The present simulator is now capable of executing all 5 scenarios, which are described below .

2.1 The Communication Scenarios

Through the use of the five scenarios, it is posssible to study all the different possible combinations of types and modes of calls. The five scenarios are described below:

(1). Single Hop System:

For those calls which require the communication between two mobile units, without going through a gateway, we group them together and form scenario 1. In this scenario, a mobile will generate a call, for which the call will go up to the satellite, and be transponded down directly to the destination mobile. This can be seen in

figure 2.1.

(2). Double Hop, Single Gateway System:

For those calls which require communication between two mobile units by going through a gateway, we group the together and form scenario 2. In this scenario, a mobile will initiate a call, which will be transponded by the satellite to a gateway. After processing by the gateway, the call is once again transponded by the satellite to the destination mobile. This can be seen in figure 2.2.

(3). Double Hop, Double Gateway System:

For those calls which have to go through two gateways, we form scenario 3. In this scenario a mobile will generate a call, which is transponded to a gateway. The gateway fowards the call to the master control station. The master control station then routes the call to the destination gateway. Then the call is once again transponded by the satellite to the destination mobile. This can be seen in figure 2.3.

(4). Mobile-to-Wireline System

For any call that was initiated by a mobile and was desired to go through a fixed phone or to a mobile serviced by the cellular system, we have scenario 4. In this scenario, the call is initiated by the mobile and transponded by the satellite to a gateway. Then, the gateway fowards the call into the wireline network. This can be seen in figure 2.4.

(5). Wireline-to-Mobile System:

If a call is iniated by a fixed phone or mobile in a cellular system to a mobile in the LMSS,we resort to scenario 5. In this scenario a call is received from the wireline telephone network into a gateway. The call is then transponded by the satellite to the destination mobile. This can be seen in figure 2.5.

2.2 Output Facilities

Also new in the present simulator is the revised version of the Master Controller (see 4.1.2, first report). In the present simulator it is possible to go through a range of values for any one of the components in the scenario. It is possible to consider a range of values for up to 14 different components simultaneously. Previously, if a type 2 measurement was chosen, the simulator would display a two column table of the input vs output SNR values, for a given set of system parameters. With the present simulator it is possible in a type 2 measurement for the simulator to display up to 15 columns (15 th column is output signal to noise ratio), one for each range of component values. In the present simulator, it is also possible to get plots of the input vs. output SNR values for any range of values of the other components (see section 5, "Sample Runs"). The looping or ranging feature mentioned above can also be used in a type 1 measurement, were the input signal, output signal (no disturbances present), and output signal (with all specified disturbances) are displayed in a table. It is now possible to consider a type 1 measurement over a range of values (up to 14 possible ranges of parameters). Once again, a plotting facility is available for every type 1 measurement table displayed (see section 5,"Sample Runs").

The revised master controller function has the following algorithm:

```
************************************************************************
/SIMULATION MASTER CONTROLLER FUNCTION/:
  <initialize simulation master controller function>
   DO <range of Specular-to Multipath Power Ratio--UHF Uplink >
      <range of Specular-to-Multipath Power Ratio--S-Band Downlink>
      <range of Specular-to-Multipath Power Ratio--S-Band Uplink>
      <range of Specular-to-Multipath Power Ratio--UHF Downlink>
      <range of carr.-to-interf. power ratio--UHF Uplink Interference>
      <range of phase values--UHF Uplink Interference >
      <range of carr.-to-interf. power ratio--S-Band Downlink Interf>
      <range of phase values--S-Band Downlink Interference>
      <range of carr.-to-interf. power ratio--S-Band Uplink Interf.>
      <range of phase values--S-Band Uplink Interf.>
      <range of carr.-to-interf. power ratio--UHF Downlink Interf>
      <range of phase values--UHF Downlink Interf.>
      <RANGE OF SNR  >
      <calculate SNR>
      <calculate standard deviation for white noise>
      <perform simulation reset>
      <set flag for mobile transmitter>
      <PERFORM a simulation run>
      <perform master controller instrumentation package>
  END <signal to noise ratio>
END /simulation master controller function/
************************************************************************
```

2.3 System Structure

The present modular structure can be seen in the flowchart of figure 2.6, with its subroutines defined in table 2.7.

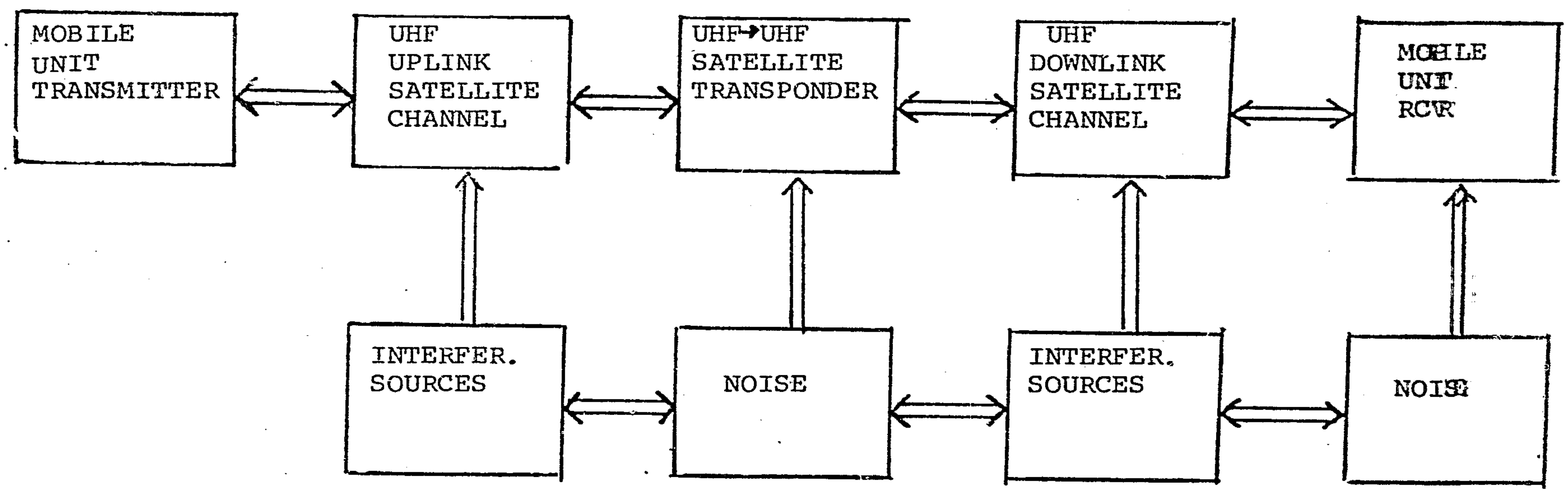

Figure 2.1 ; Single Hop Single Gateway System

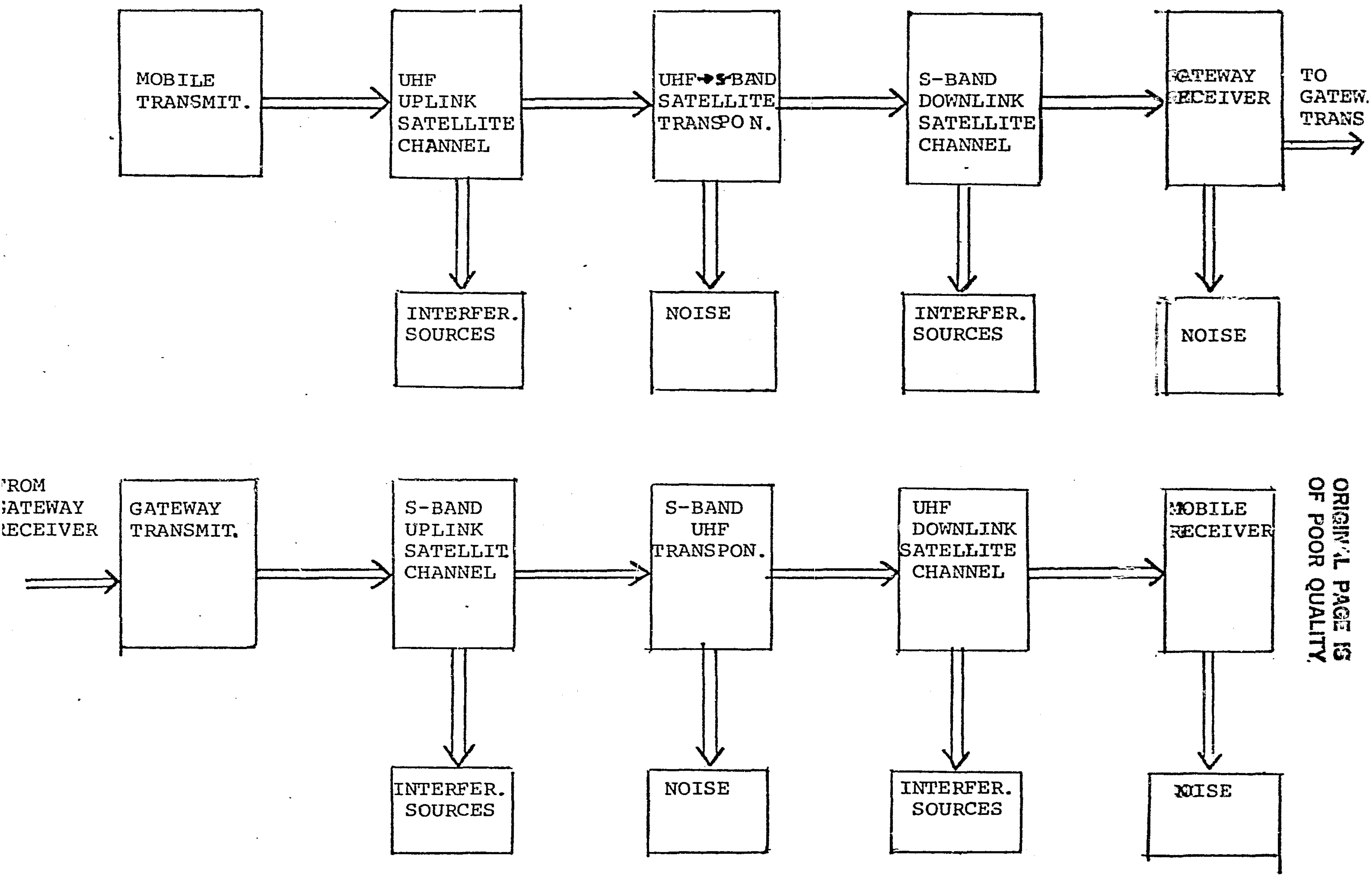

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Figure 2.2 : Double Hop Single Gateway

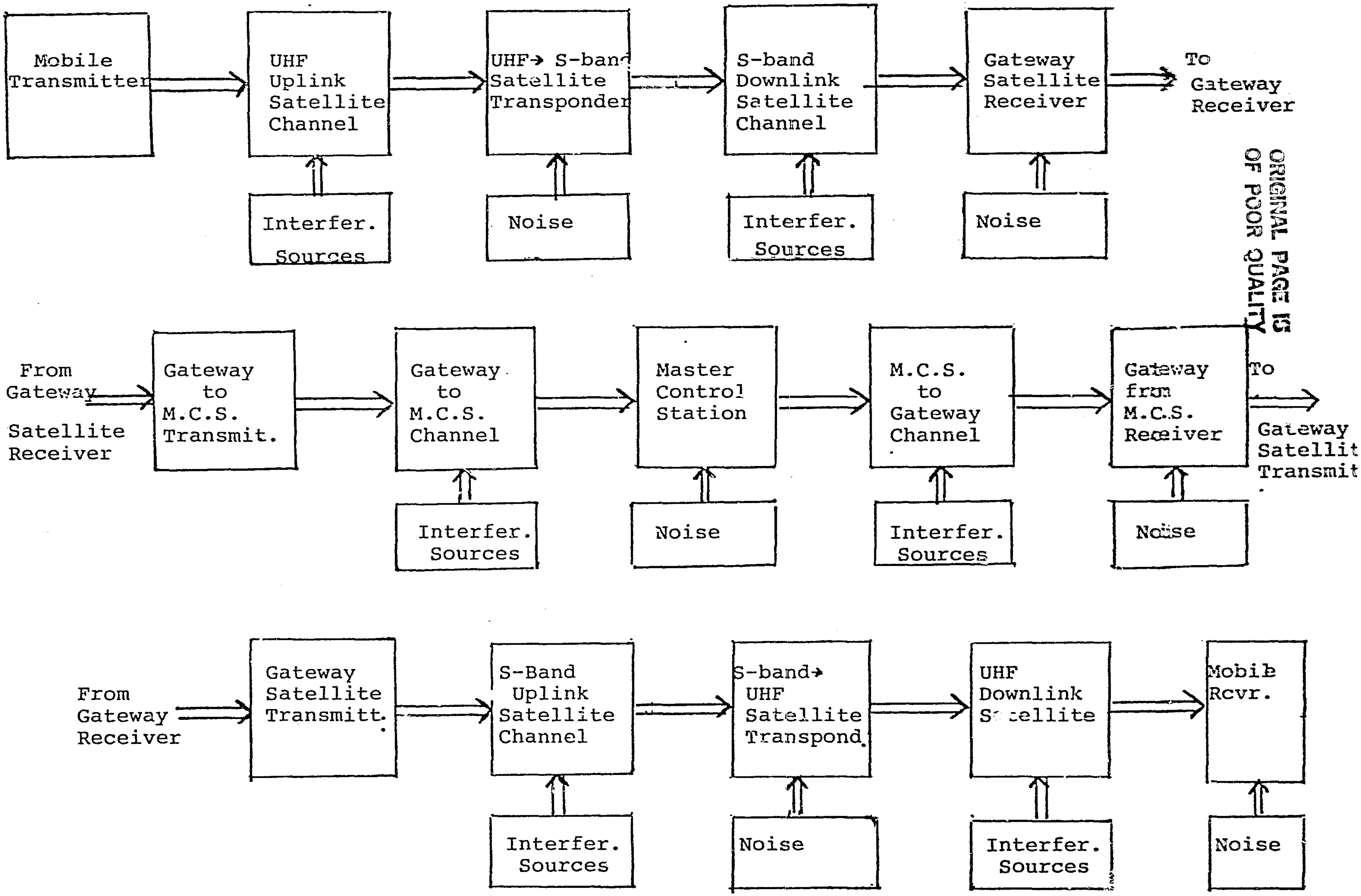


Figure 2.3 : Double Hop Double Gateway

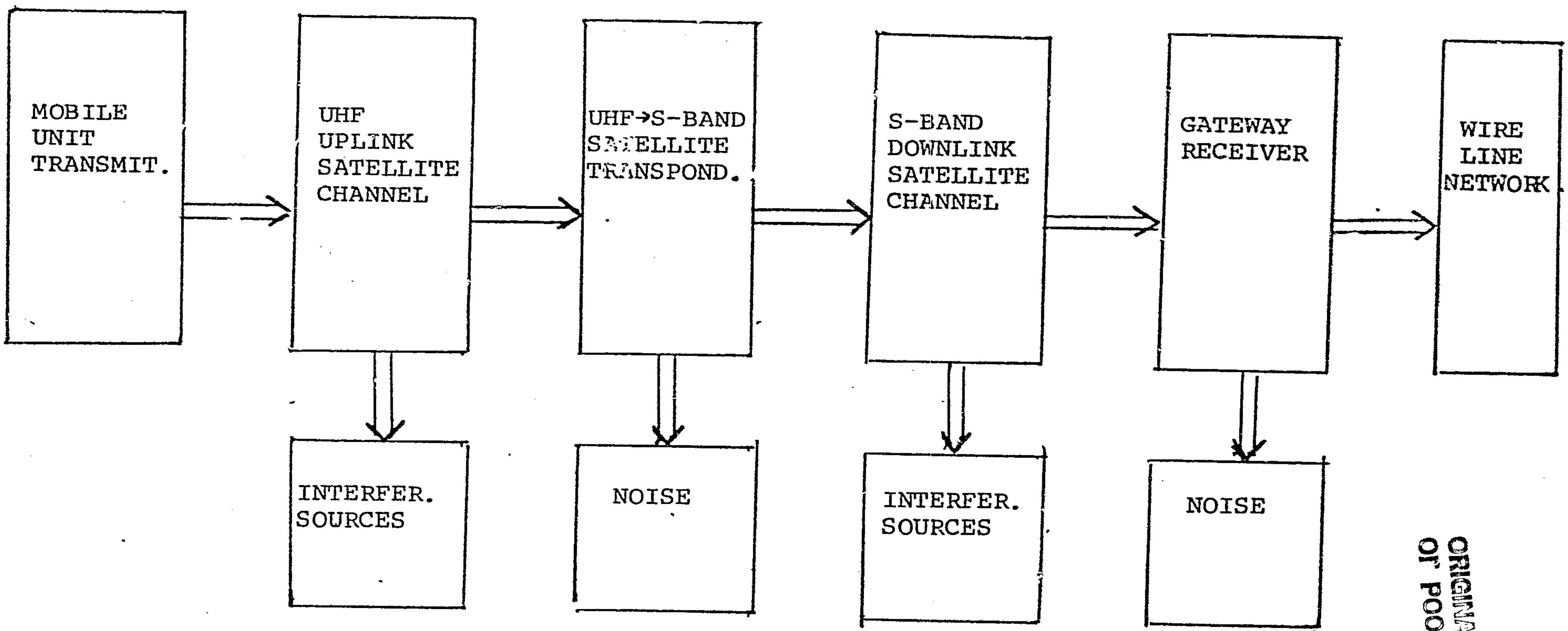


Figure 2.4 : Mobile to Wireline System

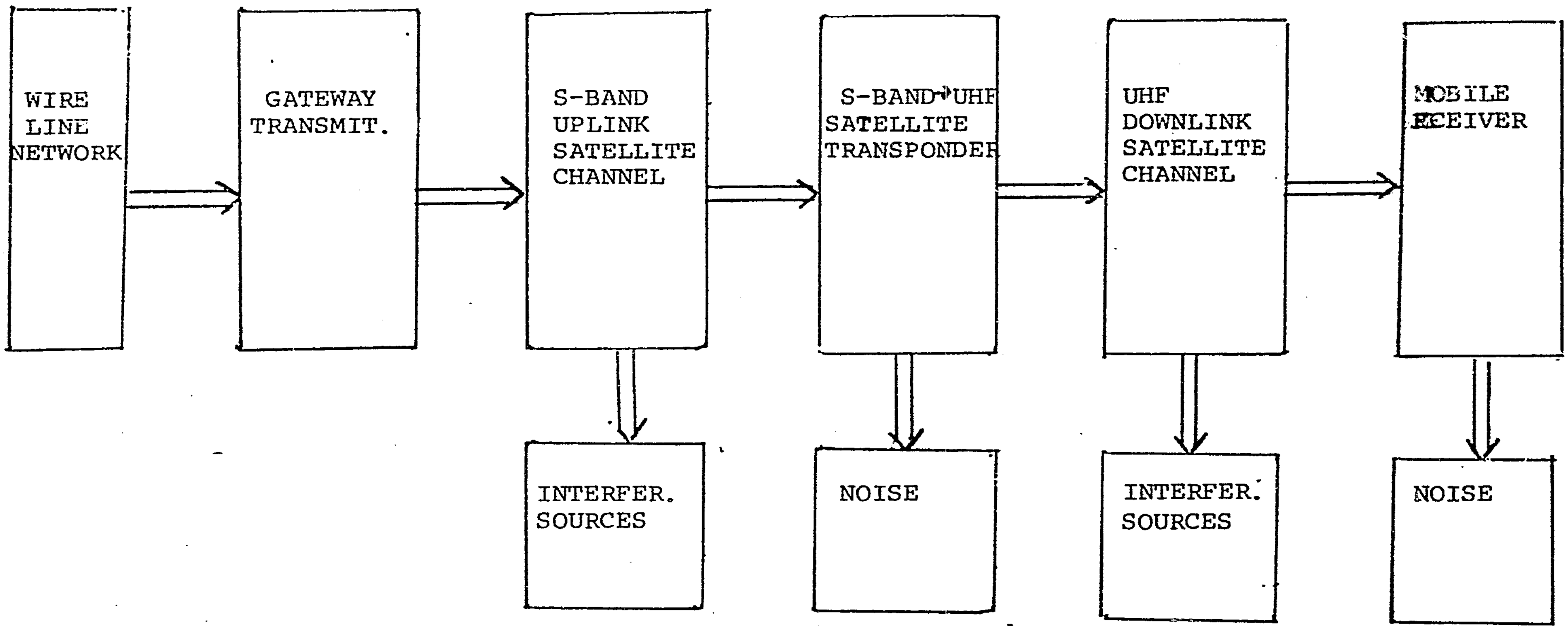


Figure 2.5 : Wireline to Mobile System

```
****************************************************************
****************************************************************
*************** LMSS SIMULATOR  ********************************
****************************************************************
                FLOW CHART OF LMSS SIMULATOR
                ----------------------------

MAIN
   ^
   ^
   ^
   SELECT
   SETUP------------------------------------------->(1)
   SETCON
   MASCON
        ^
        ^
        SETMC
        RESET----------------------------------->
        SUBCON-------------->                    ^
        INSTRM               ^                   RSTUPK-->GAUS
                            ENDSIM               RSTDLK-->GAUS
                            SCENAR-->            RSTPLT
                            UPCON    ^           SIGSRC
                                     ^
                                   ^-SCEN1-->(2)
                                   ^ SCEN2-->(3)
            SELECT ONE------------>^ SCEN3-->(4)
                                   ^ SCEN4-->(5)
                                   ^-SCEN5-->(6)

****************************************************************
****************************************************************
****************************************************************
****************************************************************
```

```
****************************
  SET-UP ROUTINES FOR EACH
         SCENARIO
****************************
```

```
(1)
 ^
 ^
 ^                         SCENARIO 1
 ^
 SETMSX------------------------------------->SETSSG
 SETIS1                                      SETMOD
 SETUSC----->SETCFG                          SETSPX--->SETCOM
 SETNG1      SETFAD                          SETNL     SETEMP
 SETUUT                                      SETFLR    SETDEL
 SETIS6                                                SETPDL
 SETSUC----->SETCFG
 SETNG6      SETFAD
 SETMSR------------------------------------->SETRSP
                                             SETEMD
                                             SETRCF
                                             SETSPR--->SETDPH
                                                       SETEXP

                        SCENARIO 2

SETMSX------------------------------------->SETSSG
SETIS1                                      SETMOD
SETUSC--->SETCFG                            SETSPX--->SETCOM
SETNG1    SETFAD                            SETNL     SETEMP
SETUBT                                      SETFLR    SETDEL
SETIS2                                                SETPDL
SETSBC
SETNG2
SETGSR
SETGAT
SETGSX
SETIS5
SETBSC
SETSUT
SETIS6
SETSUC--->SETCFG
SETNG6    SETFAD
```

```
SETMSR----------------------------------->SETRSP
                                          SETFMD
                                          SETRCF
                                          SETSPR--->SETDPH
                                                    SETEXP
```

SCENARIO 3

```
SETMSX----------------------------------->SETSSG
SETIS1                                    SETMOD
SETUSC------>SETCFG                       SETSPX--->SETCOM
SETNG1       SETFAD                       SETNL     SETEMP
SETUBT                                    SETFLR    SETDEL
SETIS2                                              SETPDL
SETSBC
SETNG2
SETGSR
SETGAT
SETGCX
SETIS3
SETGCC
SETNG3
SETMCS
SETIS4
SETCGC
SETNG4
SETGCR
SETGSX
SETIS5
SETBSC
SETNG5
SETSUT
SETIS6
SETSUC------>SETCFG
SETNG6       SETFAD
SETMSR----------------------------------->SETRSP
                                          SETFMD
                                          SETRCF
                                          SETSPR--->SETDPH
                                                    SETEXP
```

SCENARIO 4

```
SETMSX------------------------------------------->SETSSG
SETIS1                                             SETMOD
SETUSC------->SETCFG                               SETSPX--->SETCOM
SETNG1        SETFAD                               SETNL     SETEMP
SETUBT                                             SETFLR    SETDEL
SETIS2                                                       SETPDL
SETSBC
SETNG2
SETGSR
SETGAT
SETWNR
```

SCENARIO 5

```
SETWNX
SETGAT
SETGSX
SETIS5
SETBSC
SETNG5
SETSUT
SETIS6
SETSUC----->SETCFG
SETNG6      SETFAD
SETMSR----------------------------->SETRSP
                                    SETFMD
                                    SETRCF
                                    SETSPR------>SETPDH
                                                 SETEXP
```

```
************************************************************
************************************************************
```

```
****************************************************************************
****************************************************************************


                          ***************
                          *             *
                          ** SCENARIO 1 **
                          *             *
                          ***************


(2)
 ^
 ^
 ^
 MSXMTR------------------------------------------->SIGSRC
 INTFS1                                             STPRXT--------------->COMPRS
 UPMTSC------------------------------->FADE         MODSIG---->PHASE      PEMPHA
 NOISE1                                 MPCOEFF     NONLIN      QUAD      DEVLTM
 SATLT                                         ^    FLTR                  PDEVLT
 INTFS6                                        ^
 DNSTMC---------------------------->          GAUS
 NOISE6--------------------->     ^           DOPFLT
 MSRCVR-------->            ^     ^
 INSTRS         ^           ^     ^
                ^           ^     FADE---->MPCOEFF--------->GAUS
                ^           ^     FADE---->                  DOPFLT
                ^           ^              ^
                ^           ^             MPCOEFF-------->GAUS
                ^           ^                              DOPFLT
                ^           ^
                ^          GAUSS
                ^          GAUSS
                ^
                ^
                RSPDIV----------------------------------------->LPFLT1
                FMDEMO---------------->FMDCRT                    LPFLT1
                STPRRC--->DEMPH1       RCFLTR-->LPFLT
                           EXPAND


****************************************************************************
****************************************************************************
```

```
*****************************************************************
*****************************************************************

                    ****************
                    *              *
                    ** SCENARIO 2 **
                    *              *
                    ****************

(3)
 ^
 ^
 ^
 ^
 MSXMTR-----------------------------SIGSRC
 INTFS1                              STPRXT------>COMPRS
 UPMTSC--->FADE                      MODSIG--->    PEMPHA
 NOISE1    MPCOEFF--->GAUS           NONLIN   ^    DEVLIM
 SATLT                DOPFLT         FLPTR    ^    PDEVLI
 INTFS2                                       ^
 DNSTGC                                       ^
 NOISE2                                       PHASE
 GSRCVR                                       QUAD
 GATE
 GSXMTR
 INTFS5
 UPGTSG
 NOISE5
 SATLT
 INTFS6
 DNSTMC------------------->FADE--------------------->
 NOISE6---------->GAUSS    FADE------->             ^
 MSRCVR------>    GAUSS               ^             ^
 INSTRS      ^                        MPCOEFF       ^
             ^                              ^       ^
             ^                             GAUS     ^
             ^                             DOPFLT   ^
             ^                                      ^
             ^                                     MPCOEFF
             ^                                           ^
             ^                                          GAUS
             ^                                          DOPFLT
```

```
RSPDIV--------------------------->
FMDEMO------------------->       ^
SIPRRC------>             ^       ^
            ^             ^       LPFLT1
            ^             ^       LPFLT1
            ^             ^       CHOICE
            ^             ^
            ^             FMDCRI
            ^             RCFLTR
            ^                  ^
            ^                  LPFLT
            DEMPHA-->
            EXPAND  ^
                    ^
                    LPFLT2
```

```
*********************************************************************
*********************************************************************
*********************************************************************
*********************************************************************
```

```
****************
*              *
** SCENARIO 3 **
*              *
****************
```

```
(4)
 ^
 ^
 ^
 ^
 MSXMTR------------------------------------>SIGSRC
 INTFS1                                     SIPRXT------->COMPRS
 UPMTSC------->FADE                         MODSIG-->       PEMPHA
 NOISE1         ^                           NONLIN  ^       DEVLIM
 SATLT          MPCOEFF                     FLTR    ^       PDEVLI
 INTFS2               ^                             ^
 DNSTGC               GAUS                          PHASE
 NOISE2               DOPFLT                        QUAD
 GSRCVR
 GATE
```

```
HCXMTR
INTFS3
GTCC
NOISE3
MSTRCS
INTFS4
CTGC
NOISE4
GCRCVR
GATE
GSXMTR
INTFS5
UPGTSC
NOISE5
SATLT
INTFS6
DNSTMC---------------------------------->FADE------>
NOISE6---------------------->GAUSS       FADE--->  ^
MSRCVR--------->             GAUSS              ^  MPCOEFF
               ^                                ^        ^
               ^                                ^        GAUS
               ^                                MPCOEFF  DOPFLT
               RSPDIV----------------------->          ^
               FMDEMO----------->           ^           GAUS
               SIPRRC-->        ^           LPFLT1      DOPFLT
                       ^        ^           LPFLT1
                       ^        ^           CHOICE
                       ^        ^
                       ^        FMDCRI
                       ^        RCFLTR---->LPFLT
                       ^
                       DEMPHA--->LPFLT2
                       EXPAND

*****************************************************************
*****************************************************************
```

```
**********************************************************
**********************************************************

                    ***************
                    *             *
                    ** SCENARIO 4 **
                    *             *
                    ***************

(5)
 ^
 ^
 ^
 ^
 MSXMTR------------------------------------------>SIGSRC
 INTFS1                                            SIPRXT----->
 UPMTSC-------->FADE                               MODSIG-->  ^
 NOISE1           ^                                NONLIN  ^  ^
 SATLT          MPCOEFF                            FLPTR   ^  ^
 INTFS2              ^                                     ^  ^
 DNSTGC             GAUS                                   ^  COMPRS
 NOISE2             DOPFLT                                 ^  PEMPHA
 GSRCVR                                                    ^  DEVLIM
 GATE                                                      ^  PDEVLT
 WNCVR                                                     ^
 INSTRS                                                    ^
                                                           PHASE
                                                           QUAD

**********************************************************
**********************************************************
```

```
******************************************************************
******************************************************************

                        ***************
                        *             *
                        ** SCENARIO 5 **
                        *             *
                        ***************


(6)
 ^
 ^
 ^
 ^
 WNMXTR
 GATE
 GSXMTR
 INTFS5
 UPGTSC
 NOISE5
 SATLT
 INTFS6
 DNSTMC----------------------------------------->FADE--->
 NOISE6----------------->GAUSS                   FADE   ^
 MSRCVR----->            GAUSS                     ^   MPCOEFF
 INSTRS     ^                                      ^         ^
            ^                                      ^         GAUS
            ^                                      ^         DOPFLT
            RSPDIV------------------------------>  ^
            FMDEMO--------------------->      ^   MPCOFF
            SIPRRC-->              ^          ^        ^
                    ^              ^          ^        GAUS
                    ^              ^          ^        DOPFLT
                    ^              ^          ^
                    ^              ^          LPFLT1
                    ^              ^          LPFLT1
                    ^              ^          CHOICE
                    ^              ^
                    ^              FMDCRI
                    ^              RCFLTR---->LPFLT
                    ^
                    DEMPHA---->LPFLT2
                    EXPAND

******************************************************************
******************************************************************
```

```
*******************************************************************
*******************************************************************

                    LMSS SIMULATOR

**********************************************************************
```

Subprocedures Dictionary:

CHOICE	space diversity receiver controller
CTGC	master control station to gateway channel
DNSTGC	S-band downlink satellite channel
DNSTMC	UHF downlink satellite channel
ENDSIM	test if it is end of simulation
FLTR	quadrature components filtered
FMDCRI	FM discriminator
FMDEMO	FM demodulator
GATE	gateway
GAUSS	gausian generator
GCRCVR	gateway from master control station rcvr
GCXMTR	gateway to master control station xmtr
GSRCVR	gateway from satellite rcvr
GSXMTR	gateway to satellite xmtr
GTCC	gateway to master control station channel
INSTRM	update simulation master-control report
INSTRS	update simulation sub-control report
INTFS1	interference sources 1
INTFS2	interference sources 2
INTFS3	interference sources 3
INTFS4	interference sources 4
INTFS5	interference sources 5
INTFS6	interference sources 6
MASCON	simulation master control function
MODSIG	modulation of the input sample
MSRCVR	mobile from satellite rcvr
MSTRCS	master control station
MSXMTR	mobile to satellite xmtr
NOISE1	noise generator 1
NOISE2	noise generator 2
NOISE3	noise generator 3
NOISE4	noise generator 4
NOISE5	noise generator 5
NOISE6	noise generator 6
NONLIN	nonlinearity routine
PHASE	calculation of the phase angle
QUAD	claculation of the quadrature components
RANDOM	random number generator

REPORT	report generator
RESET	(re)initialization for a simulation run
RSPDIV	space diversity receiver
SATLT	the satellite
SCENAR	scenario execution selection
SCEN1	scenario 1
SCEN2	scenario 2
SCEN3	scenario 3
SCEN4	scenario 4
SCEN5	scenario 5
SELECT	selection of call to be simulated
SETBSC	initialize S-band uplink satellite channel
SETCGC	initialize master control station to gateway channel
SETFLR	initialization of the filter
SETCON	initialize the simulateion control function
SETFMD	initialization of FMDEMO routine
SETGAT	initialize gateway
SETGCC	initialize gateway to master control station channel
SETGCR	initialize gateway from master control station rcvr
SETGCX	initialize gateway to master control station xmtr
SETGSR	initialize gateway from satellite rcvr
SETGSX	initialize gateway to satellite xmtr
SETIS1	initialize interference sources 1
SETIS2	initialize interference sources 2
SETIS3	initialize interference sources 3
SETIS4	initialize interference sources 4
SETIS5	initialize interference sources 5
SETIS6	initialize interference sources 6
SETMC	initialize simuation master control function
SETMCS	initialize master control station
SETMOD	initialization of modulator
SETMSR	initialize mobile from satellite rcvr
SETMSX	initialize mobile to satellite xmtr
SETNG1	initialize noise generator 1
SETNG2	initialize noise generator 2
SETNG3	initialize noise generator 3
SETNG4	initialize noise generator 4
SETNG5	initialize noise generator 5
SETNG6	initialize noise generator 6
SETNL	initialization of nonlinearity
SETRCF	initialization of RCFLTR routine
SETRSP	initialization of RSPDIV routine
SETSBC	initialize S-band downlink satellite channel
SETSSG	initialization of the signal generator
SETSUC	initialize UHF downlink satellite channel
SETSUT	initialize S-band to UHF satellite transponder
SETUBT	initialize UHF to S-band satellite transponder

SETUP	initialization of simulation run
SETUSC	initialize UHF uplink satellite channel
SETUUT	initialize UHF to UHF satellite transponder
SIGSRC	sample generator
SETWNR	initialize wireline network rcvr
SETWNX	initialize wireline network xmtr
SUBCON	simulation sub-control function
UPCON	update the simulation control function
UPGTSC	S-band uplink satellite channel
UPMTSC	UHF uplink satellite channel
WNRCVR	wireline network rcvr
WNXMTR	wireline network xmtr

---

3. Processing Voice Via The Simulation

One of the systems greatest present attributes is its ability to process voice. The present simulator can be utilized to listen to any of the following effects on voice (via each of the five scenarios):

(a). Listen to the effects of noise.

(b). Listen to the effects of interference.

(c). Listen to the effects of modulation.

(d). Listen to the effects of the fading channel.

(e). Listen to the effects of filtering on the voice.

(f). Listen to the effects of the space diversity receiver.

(g). Listen to the effects of the satellite nonlinearity.

(h). Listen to the effects of varying sampling rates.

(i). All combinations of the above.

An analysis of a number of the above tests are included within the report (see section 6.2).

A basic model of how to use the simulation to process voice is shown in figure 3.1. In this model, an analog to digital converter samples voice at a rate of at least 8 kilohertz (minimum sampling rate for voice bandlimited to 4000 Hz.), producing 12 bit samples. In the second stage, these 12 bit samples are converted into 16 bit integer format (IBM format). These 16 bit integers are then read by the LMSS simulator. (see section users manual

for simulator voice setup). The output of the LMSS simulator is then converted from 32 bit floating point form (IBM format) back into a 12 bit integer format by the fourth stage. In the fifth stage, a digital to analog converter with the proper hardware connected, converts the samples into voice. In between each of the above stages, any type of storage device could have been used for intermediate storage.

The system outlined above is general, and actual implementation depends on the particular intermediate systems involved (stages 1,2,4,and 5).

In figure 3.2 we have a detailed block diagram of the specific algorithim we used in implementing what was shown in figure 3.1.

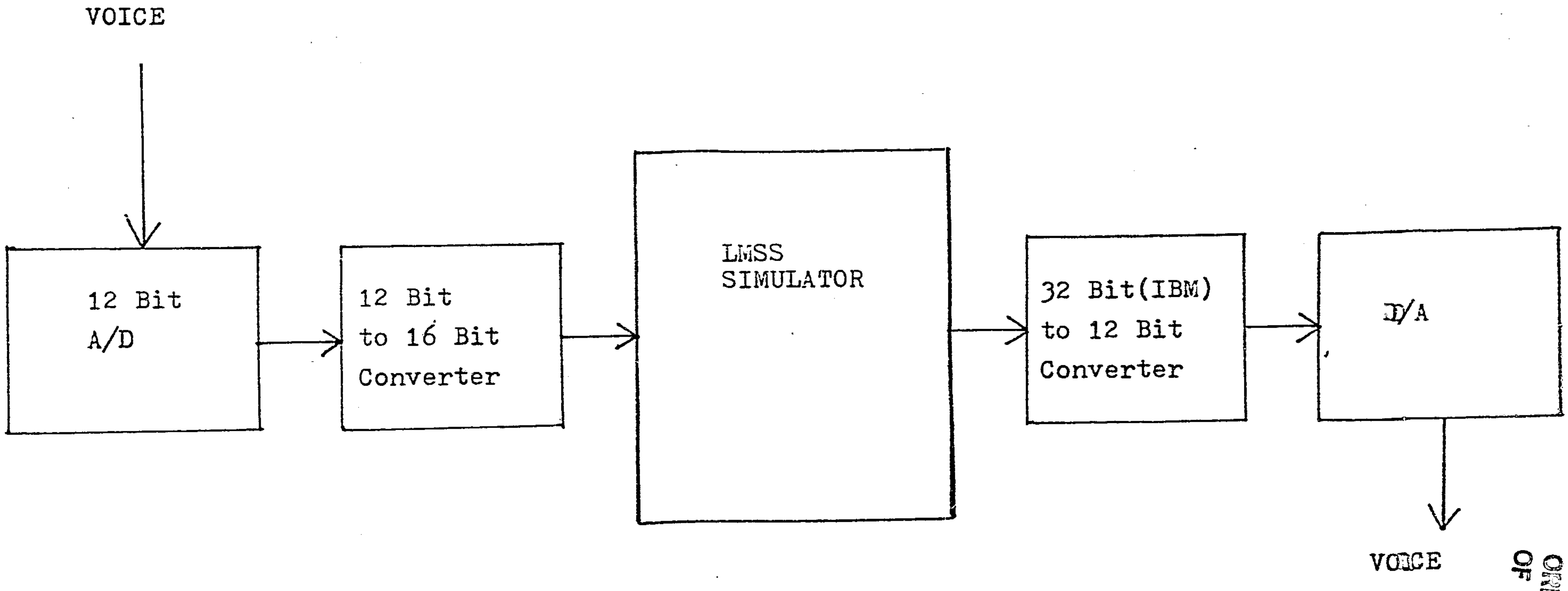
The first stage consisted of a 12 bit analog to digital converter interfaced into a Hewlett Packard 1000 (HP 1000) computer system. This system sampled the voice (bandlimited to 4000 Hz) with a sampling rate of 8 Khz, and stored it on tape with a "WRITT" format (This is an HP utility which stores data onto a tape in an ultra-condensed coded format, which can only be read by another HP system). We had to store it in this form because the system we used didn't have enough storage facilty to do it any other way. In the next stage, we used another HP 1000, with much greater storage facility to convert the WRITT format tape into straight ASCII data. For error control and checking purposes, data was stored in the format of an integer (16 bit integer, represented by 4 characters) followed by a space.

This tape was now to be mounted on the IBM machine. We used the program shown in figure 3.3 to convert from ASCII into EBCDIC

(IBM) format. We stored the data on a disc. We than used the LMSS simulator to process the voice samples.

The LMSS simulator has the facility to read in integers (16-bit) in the format mentioned above. The simulator then interpolates between these samples if specified by the user, and then processes them. The output data set is a stream of 32-bit (IBM format) floating point numbers. Module 3.4 (see figure 3.4) is then used to convert this 32-bit data stream into a 16 bit interger data stream (format 16(1x,I4)), with sample values normalized to plus or minus 2047 (12-bit number). Module 3.5 (see figure 3.5) is then used to convert the data from EBCDIC to ASCII format, and stores it on tape. The tape is then read in by module 3.6 (see figure 3.6) using the HP-1000. This module converts data into the format needed by the digital to analog converter. Then finally the D/A converts the samples back to voice.

All the above steps were needed because of code conversions between machines as well as numerical format (the IBM is a 32-bit machine while the HP-1000 is a 16-bit machine). Ideally, one would use the setup of figure 3.1 if the proper equipment is attainable.



3.1 Voice Processing Set Up

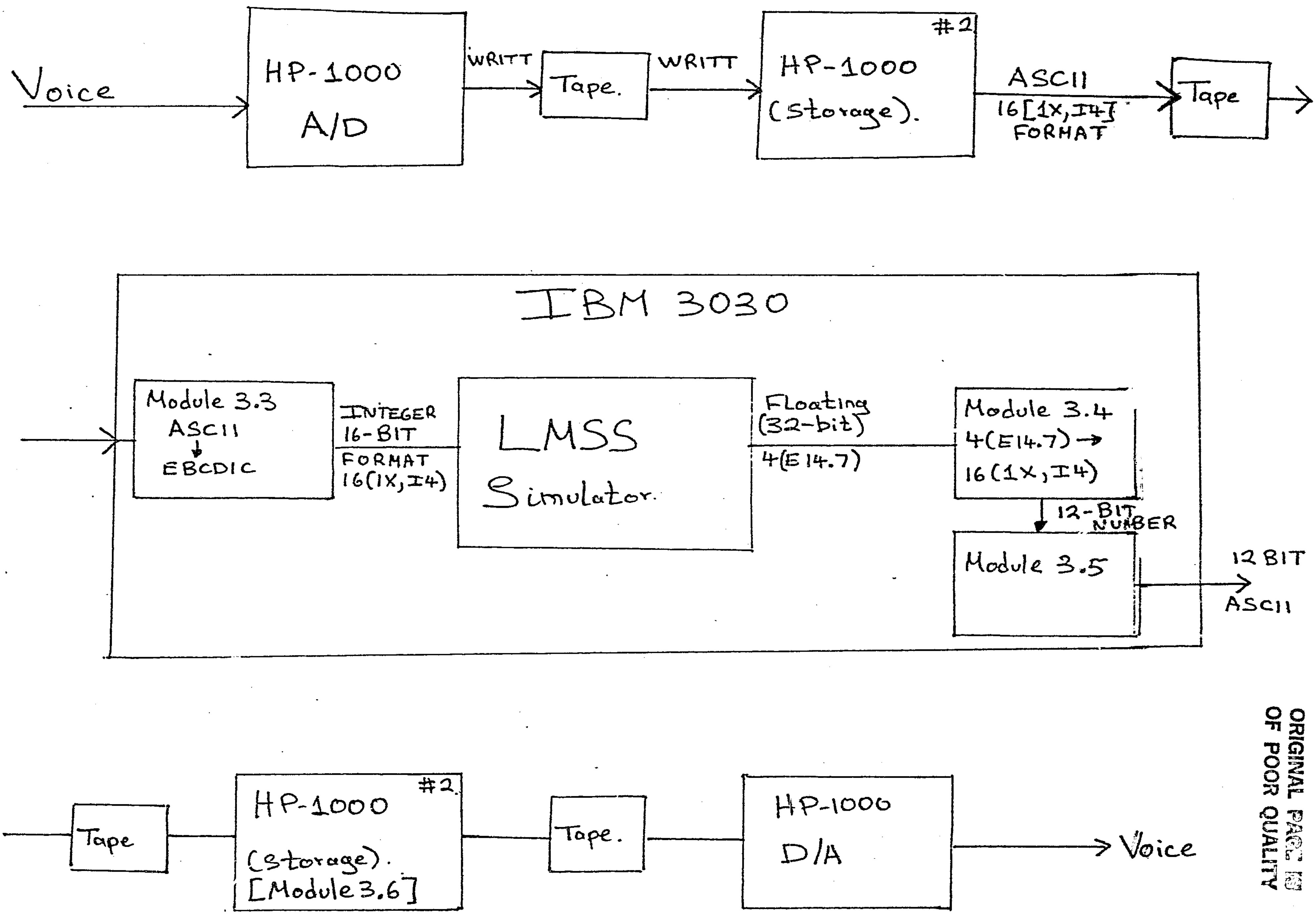

Voice
HP-1000
A/D
WRITT
Tape.
WRITT
#2
HP-1000
(Storage).
ASCII
16[1X,I4]
FORMAT
Tape
IBM 3030
Module 3.3
ASCII
EBCDIC
INTEGER
16-BIT
FORMAT
16(1X,I4)
LMSS
Simulator.
Floating
(32-bit)
4(E14.7)
Module 3.4
4(E14.7) →
16(1X,I4)
12-BIT
NUMBER
Module 3.5
12 BIT
ASCII
Tape
#2
HP-1000
(storage).
[Module 3.6]
Tape.
HP-1000
D/A
Voice

Figure 3.3


```
    This program reads a tape in ASCII format, and converts it to a
file in EBCDIC format (File: TAPRD)


// JOB
//STEP1 EXEC PGM=PRESS
//SYSPRINT DD SYSOUT=A
//SYSIN DD DUMMY
//SYSUT1 DD DSN=ONE,DISP=(OLD,PASS),LABEL=(1,NL),VOL=SER=CCT280,
// UNIT=TAPE,DCB=(LRECL=80,BLKSIZE=80,RECFM=FB,DEN=3,OPTCD=Q)
//SYSUT2 DD DSN=WYL.CC.BHC.TAPRD,UNIT=3330,DISP=(,CATLG),
// VOL=SER=SCR002,DCB=(LRECL=6233,BLKSIZE=6233,RECFM=U,DSORG=PS),
// SPACE=(TRK,(20,5),RLSE)
/*
//
```

Figure 3.4


```
     This program reads a file of 32 bit floating point numbers
(format 4(E14.7) per record), and converts them into a file of 12
bit numbers (integers ), for use in the D/A system.



// JOB TIME=4,REGION=400K
//*MAIN LINES=50
// EXEC FORTGCG
//FORT.SYSIN DD *
C  ********************************************************************
          REAL MAX
          DIMENSION X(32768),IX(32768)
          MAX=0
             READ(1,100,END=200) (X(J),J=1,32768)
 100         FORMAT(4(E14.7))
               DO 55 J=1,32768
                 IF (ABS(X(J)).GT.MAX) MAX=ABS(X(J))
 55            CONTINUE
            PRINT 70,MAX
 70       FORMAT(' ','MAX=',E14.7)
            DO 66 J=1,32768
            X(J)=X(J)/MAX
            X(J)=X(J)*2046.
             X(J)=X(J)+2047.
            X(J)=X(J)+.5
            IX(J)=X(J)
 66         CONTINUE
             WRITE(2,333) (IX(J),J=1,32768)
 333         FORMAT(16(1X,I4))
 200         CONTINUE
              STOP
              END
//GO.FT01F001 DD DSN=WYL.CC.BHC.RS1B,DISP=SHR
//GO.FT02F001  DD  DSN=WYL.CC.PUB.XS1B,UNIT=3330,
// DISP=(NEW,CATLG,CATLG),SPACE=(TRK,(14,5),RLSE),
//     VOL=SER=SCR003,
//     DCB=(DSORG=PS,RECFM=FB,LRECL=80,BLKSIZE=6160)
//GO.SYSIN DD *
```

Figure 3.5


```
     This program takes a file in EBCDIC format (FILE11)
 and stores it on tape in ASCII format.


// JOB TIME=5,REGION=800K
//STEP1 EXEC PGM=IEBGENER
//SYSPRINT DD SYSOUT=A
//SYSIN DD DUMMY
//SYSUT1 DD DSN=WYL.CC.PUB.FILE11,DISP=SHR,
//             UNIT=SYSDA
//SYSUT2 DD DSN=ONE,UNIT=TAPE,DCB=(LRECL=80,BLKSIZE=80,RECFM=FB,
// DEN=3,OPTCD=Q),VOL=SER=CCT004,LABEL=(1,NL),DISP=(NEW,KEEP)
/*
//STEP6 EXEC PGM=PRESS
//SYSPRINT DD SYSOUT=A
//SYSIN DD DUMMY
//SYSUT1 DD DSN=ONE,DISP=(OLD,KEEP),LABEL=(1,NL),VOL=SER=CCT004,
// UNIT=TAPE,DCB=(LRECL=80,BLKSIZE=80,RECFM=FB,DEN=3,OPTCD=Q)
//SYSUT2 DD DSN=WYL.CC.PUB.NASA,UNIT=3330,DISP=(,CATLG),
// VOL=SER=SCR002,DCB=(LRECL=6233,BLKSIZE=6233,RECFM=U,DSORG=PS),
// SPACE=(TRK,(400,5),RLSE)
/*
//
```

Figure 3.6

```
      PROGRAM GDATA
C
C     DEVELOPED BY:     HARI P. SINGH
C                       DECEMBER 1982
C
C  THIS PROGRAM IS DESIGNED TO READ ASCII DATA OFF A TAPE,CONVERTS IT
C  INTO HP FLOATING POINT FORMAT,AND THEN STORE IT IN A TYPE 1 FILE.
C  IT IS ASSUMED THAT THE ORIGINAL DATA IS STORED ON THE TAPE IN 80
C  COLUMN RECORDS 16(1X,2A2),AND THAT AFTER EVERY 2048 RECORDS A NEW
C  FILE IS TO BE CREATED.
C
      INTEGER I,                      ! GENERAL PURPOSE COUNTER
     +        IBUFF(40),              ! I/O BUFFER
     +        IDCB(144),              ! DATA CONTROL BLOCK FOR FMP CALLS
     +        IERR,                   ! ERROR RETURN AFTER FMP CALLS
     +        INAM(3),                ! NAME OF THE TYPE 1 DISC FILE
     +        ISIZE(2),               ! SIZING INFORMATION FOR THE TYPE 1 FILE
     +        ITYPE,                  ! FMP FILE TYPE
     +        ITEMP,                  ! INTEGER AFTER CONVERSION FROM ASCII
     +        J,                      ! GENERAL PURPOSE COUNTER
     +        TRBUFF(3)               ! FOR CALLS TO DECODE
C
      REAL    RBUFF(64)               ! BUFFER CONTAINING 64 REALS/RECORD
C
      DATA ISIZE /512,128/
      DATA ITYPE /1/
C
C
 0010 WRITE(1,0025)
 0025 FORMAT('WHAT DO YOU WANT TO NAME THIS FILE ')
      READ '(3A2)',INAM
C
      CALL CREAT(IDCB,IERR,INAM,ISIZE,ITYPE,ISC,32767)
      IF(IERR.LT.0)THEN                          ! FMP ERROR
         WRITE(1,0030)IERR                       ! WRITE ERROR MESSAGE
 0030    FORMAT('FMP ERROR NUMBER ',I4,' WHILE BUILDING DISC FILE')
         GO TO 9999                              ! EXIT PROGRAM
      ENDIF
C
      DO 1000 IREC=1,512              ! (512 RECORDS)*(64 POINTS/RECORD)
         DO 0900 J=1,4                ! 4 RECORDS ON TAPE MAKE ONE ON DISC
            READ(8,0100)IBUFF         ! READ A RECORD
 0100       FORMAT(40A2)
 0200       FORMAT(1X,I4,3X,40A2)
C
C   THIS LOOP IS USED TO DECODE THE ASCII DATA. IN EACH OF THE EIGHT
C   ITERATIONS,TWO OF THE 16 INTEGERS ARE DECODED. THE DATA ON TAPE
C   IS LAID OUT IN THE FORM 16(1X,2A2). FIRST THREE WORDS ARE BROUGHT
C   INTO TRBUFF. THESE WORDS CONTAIN 6 CHARACTERS:
C   A LEADING BLANK,FOUR CHARACTERS REPRESENTING AN INTEGER,& ANOTHER BLANK
C   THESE ARE THE INTEGERS IN POSITIONS (1,3,5,7,9,11,13,15)
C   NEXT THE FOUR CHARACTERS REPRESENTING THE INTEGERS IN POSITIONS
C   (2,4,6,8,10,12,14,16) ARE DECODED
C
            DO 0800 I=1,8             ! DECODE 2 INTGERS AT A TIME
```

```
                TRBUFF(1)=IBUFF(((I-1)*5)+1)
                TRBUFF(2)=IBUFF(((I-1)*5)+2)
                TRBUFF(3)=IBUFF(((I-1)*5)+3)
                DECODE(6,0500,TRBUFF)ITEMP
                RBUFF(((J-1)*16)+((I-1)*2)+1)=REAL(ITEMP)
                TRBUFF(1)=IBUFF(((I-1)*5)+4)
                TRBUFF(2)=IBUFF(((I-1)*5)+5)
                DECODE(4,0500,TRBUFF)ITEMP
                RBUFF(((J-1)*16)+((I-1)*2)+2)=REAL(ITEMP)
 0500           FORMAT(I6)
 0800         CONTINUE
 C
 0900       CONTINUE
 C
 CCCCC      WRITE(6,0905)RBUFF
 0905       FORMAT(4(16(1X,F5.0),/))
            CALL WRITF(IDCB,IERR,RBUFF)        ! WRITE A RECORD TO DISC
            IF(IERR.LT.0)THEN               ! FMP ERROR
              WRITE(1,0920)IERR             ! WRITE ERROR MESSAGE
 0920         FORMAT('FMP ERROR NUMBER ',I4,' WHILE WRITTING TO DISC')
              GO TO 9999                    ! EXIT PROGRAM
            ENDIF
 1000     CONTINUE
 C
          WRITE(1,0930)
 0930     FORMAT('DO YOU WISH TO BUILD ANOTHER FILE (Y/N) ')
          READ '(A2)',IANSWR
          IF(IANSWR.EQ.1HY)GO TO 0010
 9999     CONTINUE
 C
          CALL CLOSE(IDCB,IERR)             ! CLOSE FILE
            IF(IERR.LT.0)THEN               ! FMP ERROR
            WRITE(1,9030)IERR               ! WRITE ERROR MESSAGE
 9030       FORMAT('FMP ERROR NUMBER ',I4,' WHILE CLOSING FILE')
          ENDIF
 C
          END

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 **  NO WARNINGS **  NO ERRORS **   PROGRAM:   745       COMMON: (NONE)
```

4. User's Guide

This user's guide will provide the user with a step by step explanation of the questions that will be asked during a typical session with the simulator. References are given in each question so that the user can refer to the appropriate sections if an in depth discussion about the topic is desired (references made refer to the first report, "A Computer Simulator for a Mobile Telephone System", NASA Grant 3-119).

The following is a typical question-and-answer session with all the possible questions either being asked or presented in the explanation. The answers shown here are for a batch version version for a run. In an actual run, the answers shown would come out on the same line as the question. However we have seperated them here onto seperate lines for clarity. For an online session, merely the question will be prompted unto the user terminal, for which he would interactively enter his response.

The first question asked prompts the user as to whether the session is an online or batch session, and is displayed as follows:

```
Is this an online session? (Y/N)                        (1)
                              N
```

The user should answer a 'Y' if it is an online session, or an 'N' if it is a batch session. In this case the response is "N" (no).

Next, the type of calls that are available in the communication system are displayed as follows:

communication system are displayed as follows:

```
TYPE OF CALL AVAILABLE:                                          (2)
1: M1->M2, rural mobile to rural mobile in same UHF beam
2: M1->M3,  rural mobile to rural  mobile in different UHF beam,
in same S-band
3: M1->M4, rural  mobile to rural mobile in different  UHF beam,
in different S-band.
4: M1->FC1, rural mobile to fixed in same S-band beam
5: M1->FC2, rural mobile to fixed in different S-band beam
6: FC1->M1, fixed to rural mobile in same S-band beam
7: FC2->M1, fixed to rural mobile in different S-band beam
INPUT TYPE OF CALL TO BE SIMULATED:
                                     1
```

Here the type of calls that are available in the communication system are displayed, each one being designated by a number from 1 through 7. Right after the list, the user is prompted to input the type of call he wishes to be simulated by inputing a number from 1 through 7. In this case, the first call ("1") was chosen. For an explanation of each of these calls, see section 2.2.

After the user has inputed the type of call to be simulated, the modes of call available within the type of call selected will be displayed (refer to section 2.3). In this case, the user chose to simulate type 1, which is rural mobile calling rural mobile in the same UHF-beam and S-beam. Correspondingly, the following choice of modes was displayed:

```
MODE OF CALL AVAILABLE:                                          (3)
1: M1->M2, hard wired transponder
2: M1->M2, direct switched transponder
3: M1->M2, indirect switched transponder
4: M1->G1->M2, double hop system
INPUT MODE OF CALL TO BE SIMULATED:
                                     1
```

Note that the type of modes that will be displayed depends on the type of call that is chosen (in this case type 1 was chosen). A full list of the range of possible modes corresponding to the

type of call chosen is found in section 2.3. (table 2.3.1).

One notes that following the list of modes available, the user is prompted to input the mode of the call by entering its corresponding number. In this case the user chose "1", from a choice of 1 to 4.

Based on the type of call an. mode of call selected, the program will determine which scenario to be simulated (refer to section 3.3). The questions asked from this point on will vary depending on the features to be simulated within the scenario. Even though each of the five scenarios are different, the questions to be answered for each of them are more or less of the same nature. Therefore the rest of our discussion will focus only on those questions that are asked when the single hop system is to be simulated (which is the case of this par.icular simulation run).

In the next question, the user is asked to choose from the types of signal sources available. Choice 1, corresponds to a program generated sinusoid which can be used for making analytical tests. If choice "1" is chosen, no further questions aout the signal source are asked and question (4) is then displayed. Choice "2" corresponds to sampled voice. If type 2 is chosen, then see section 3.2 for an explanation of procedures to be used.

```
TYPES OF SIGNAL SOURCES AVAILABLE:
1: Program generated single tone sinusoid.
2: Sampled voice from tape source.
Choose type of signal to be used (I1):
                                              1
```

In the next question,

```
FREQUENCY OF THE BASEBAND SIGNAL ( LESS THAN 3000 HZ. )        (4)
(IN HERTZ, F7.2):
                         1000.00 HZ
```

the user is asked to input the frequency of the baseband signal in hertz using the format "F7.2". The baseband signal has an upper limit of 3000 Hz (refer to section 5).

The next question displayed is as follows:

```
NOTE: POWER OF THE BASEBAND SIGNAL HAS TO BE LESS OR EQUAL   (5)
     THAN.5 WATTS;
     SO THAT THE MAXIMUM INSTANTANEOUS FREQUENCY DEVIATION IS
     LESS OR EQUAL THAN 12000 HZ
POWER OF THE BASEBAND SIGNAL(IN WATTS, F7.2):                 (6)
                                              0.50 WATTS
```

Here the user inputs the power of the baseband signal in watts using the format F7.2. The power of the baseband signal has to be less than or equal to .5 watts, so that the maximum instantaneous frequency deviation is less than or equal to 12000 Hz (refer to section 5).

In the next question that appears

```
THE CARRIER POWER (IN WATTS, F7.2):                           (7)
                                    1.00 WATTS
```

the user is asked to input the carrier signal power in watts using the format F7.2.

The next question appearing,

```
THE FREQUENCY DEVIATION (IN HERTZ, F8.2): 12000 HZ.           (8)
(FIXED FOR NOW)
```

asks the user to input the frequency deviation in Hertz using the format F8.2. Under the current version, the frequency deviation is fixed at 12,000 Hz in order for the simulator to meet AMPS specifications (refer to section 5).

The next question is displayed as follows:

```
How many times the nyquist rate do you want the sampling     (9)
frequency to be? (2 - 4, I1):
                              2
```

Here the user is asked to input the sampling frequency in terms of a multiple of the Nyquist rate. Acceptable values are from twice the nyquist rate to four times the Nyquist rate. Twice the Nyquist rate is the minimum in order for the simulator to intergrate and differentiate correctly. Four times the Nyquist rate is the maximum since any increase of the sampling frequency beyond this point will not improve any significant approximation, but will prolong run time substantially (refer to section 3.2).

In the next question,

```
THE CARRIER FREQUENCY (IN HERTZ, F7.2):(NOT USED FOR NOW)   (10)
```

the user is asked to input the carrier frequencyin Hertz using the format F7.2. Under the current version of the simulator, the carrier frequency is not used in the simulation.

The next question is displayed as follows:

```
DO YOU WANT THE COMPRESSOR/EXPANDER IN?  Y-YES , N-NO :     (11)
                                                    Y
```

Here the user is asked whether the compressor/expander (AMPS specs) are used in the transmitter and receiver (refer to section 5). This question is answered either with a "Y" (yes) or an "N" (no).

The next question appears as follows:

```
DO YOU WANT THE PRE-EMPHASIS - DE-EMPHASIS FILTERS IN ?     (12)
Y-YES , N-NO :
            Y
```

Here the user is asked whether pre-emphasis and de-emphasis filters (AMPS specs) are used in the transmitter and receiver (see section 5).

The user is then prompted as to whether or not interference is

present in the UHF uplink sattelite channel. This question is displayed as follows:

```
DO YOU WANT A CO-CHANNEL INTERFERER IN THE UPLINK?            (13)
                                   Y-YES,N-NO:
                                            Y
Are multiple values of the carrier to interference power     (14)
ratio to be tested? (Y/N):
                  Y
Input the range of values to be tested (in DB):
Input the initial value (-99 -- +99,I3):                      (15)
                                      10 DB
Input the increment value (01 -- 99,I3):                      (16)
                                      10 DB
Input the final value (01 -- 99,I3):                          (17)
                                  70 DB
Are multiple values of the interference phase values          (18)
to be tested? (Y/N):
              Y
Input the range of values to be tested (in degrees):
Input the initial value (F6.2) :                              (19)
                            10.00 DEGREES
Input the increment value (F6.2) :                            (20)
                              5.00 DEGREES
Input the final value (F6.2) :                                (21)
                           25.00 DEGREES
```

Note the answer to the first of these questions was "Y" (yes). If the response was "N" (no interference), then the next eight questions would not have appeared. However, since in this case the response is yes, they did appear. In the first of these questions (14), the user is asked if he wishes to input a range of values for the carrier to interference power ratio. If the answer is "Y" (yes), as in this case, then questions 15-17 will follow. Here, the user inputs the initial value, increment value, and final value respectively (in dB, using the format I3) of the carrier to interference power ratio. If the answer to question (14) was "N" (no), then the user would have just been asked to input one value of the carrier to interference power ratio in the same format as above. After question 17, the user is asked wether he wants to

input a range of phase values for the interference source (question 18). If the response to this is "Y" (yes), then questions 19-21 will appear, asking the user to input the initial, incremental, and final value of the phase, respectively (using format F6.2 , in degrees). If the response to question 18 was "N" (no), then a question would have appeared asking only one value for the phase.

In the next question,

```
 IS FADING PRESENT IN THE UPLINK   CHANNEL? Y-YES,N-NO:          (22)
                                                        Y
```

one responds as to whether or not the uplink satellite channel is a fading channel or not. One responds to the question by either typing a "Y" for yes or a "N" for no. If the response is no, the next five questions (questions 23-28) will not appear. However, as in this case, if the response is yes, then questions 24 through 28 will definitely appear. If interference is present, as is the case in the current simulation run, then question 23 will also appear. If interference were not present in the uplink, then question 23 would have not been asked. Questions 23-28 are displayed as follows:

```
 IS THE INTERFERENCE FADED? Y-YES,N-NO:                          (23)
                                           Y
 THE UPLINK FADING CHANNEL IS PRESENT
    TYPES OF FADING CHANNELS AVAILABLE:                          (24)
     1: NO SPECULAR COMPONENT (RALEIGH FADING)
     2: SPECULAR COMPONENT, SHORTEST PATH
     3: SPECULAR COMPONENT, MEAN PATH
     INPUT TYPE OF CHANNEL:
                         2
 ENTER THE MULTIPATH SPREAD TIME (IN MICROSECONDS, F9.2):        (25)
                                           500.00 MICROSECONDS
 ENTER THE DOPPLER SPREAD BANDWIDTH (IN HERTZ, F7.2):            (26)
                                                  1.00 HZ
```

Are multiple values of the specular to multipath power ratio to be tested? (Y/N) : (27)
N

ENTER THE SPECULAR-TO-MULTIPATH POWER RATIO (IN DB, I3): (28)
100 DB

In the first of these questions, the user respond's as to whether or not the interference is effected by the fading channel. If it is, it is done so independently of the signal and is added at the end. If it is not, then the interference is just added to the faded signal.

In the second of these questions, the user decides which type of fading is present, by entering a 1 digit number from 1 to 3 corresponding to the type of fading that is present. If (1) is chosen, then the fading channel will be a Rayleigh distributed one with no specular component. If (3) is chosen, then the channel will have Rician statistics, with the specular component in the middle. In other words, the mean path is taken. In the last case, (2), the channel has Rician statistics with the shortest path being taken (refer to section 6).

In the third of these questions (25), the user is asked to input the total multipath spread time of the fading channel in microseconds using the format F9.2. In this case, "500.00" was entered as data.

In question (26), the user is asked to input the doppler spread bandwidth of the fading channel in Hertz using the format F7.2. In this case the number "1.00" was entered as data.

Question (27) will only be asked if the response to question (24) is either 2 or 3. If the response is 1, then Rayleigh fading is being used which exhibits no specular component. Question (27)

once again asks wether or not the user wishes to input a range of values for the specular to multipath power ratios (in dB). In this case the answer is "N" (no), and thus question (28) appears , which asks the user to input only one value of the specular to multipath power ratio (in dB) using the format I3 (in this case 1ØØ was entered as data). If the response to question (27) was yes, then three questions asking for the initial, incremental, and final values respectively (using the same input format as question (28)) would have been displayed as they have in the questions asked previously.

The next question,

```
DO YOU WANT A CO-CHANNEL INTERFERER IN THE DOWNLINK?          (29)
                                          Y-YES,N-NO:
                                                    Y
Are multiple values of the carrier to interference power      (3Ø)
ratio to be tested ? (Y/N) :
                              N
INPUT CARRIER TO INTERFERENCE POWER RATIO IN DB(I3):          (31)
                                                 3Ø DB
Are multiple values of the interference phase values          (32)
to be tested ? (Y/N):
                         N
INPUT PHASE OF INTERFERENCE IN DEGREES (F7.2):                (32.1)
                                             3Ø.8Ø DEGREES
```

is the dual of the uplink interference case. The data entry is exactly the same as it were for the uplink case. Note however, in this case that the responses to the questions asking if the user wants to input a range of values are both negative. In this case the user is only inputing single values (Ø3Ø dB for the power ratio, and 3Ø.8Ø Degrees for the phase).

The next question,

```
IS FADING PRESENT IN THE DOWNLINK CHANNEL? Y-YES,N-NO:        (33)
                                                    Y
```

is basically the dual of the uplink case, the only exception however is the facility for a space diversity receiver. Once again, if the response to the above question is "N" (no), then questions 34 through 45 will not be asked. If the response is "Y" (yes), the next question that will be displayed is:

```
IS A SPACE DIVERSITY RECEIVER BEING USED? Y-YES,N-NO:        (34)
                                                   Y
```

If a space diversity receiver is being used (response "Y"), as is the case for this example, then parameters for 2 fading channels will have to be set; questions 36 through 40 for the first channel and questions 41 through 45 for the second channel. If a space diversity receiver is not being used (response "N"), then the user will only be prompted to enter parameters for one channel.

If co-channel interference is present in the downlink channel (response to (29) is "Y"), then the following question will be displayed:

```
IS THE INTERFERENCE FADED? Y-YES,N-NO:                       (35)
                                       Y
```

Here one enters whether or not the interference should be faded. If yes (as in this case), the user enters a "Y", and if not, the user enters an "N".

Questions 36 through 40 or questions 36 through 45 if a space diversity receiver is present, are entered in an analagous way as were the questions for the uplink satellite channel.

```
THE DOWNLINK FADING CHANNEL IS PRESENT
SET PARAMETERS FOR FIRST FADING CHANNEL:                      (36)
TYPES OF FADING CHANNELS AVAILABLE:
 1: NO SPECULAR COMPONENT (RALEIGH FADING)
 2: SPECULAR COMPONENT, SHORTEST PATH
 3: SPECULAR COMPONENT, MEAN PATH
```

```
 INPUT TYPE OF CHANNEL:
                        2
ENTER THE MULTIPATH SPREAD TIME (IN MICROSECONDS, F9.2):   (37)
                                      500.00 MICROSECONDS
ENTER THE DOPPLER SPREAD BANDWIDTH (IN HERTZ, F7.2):       (38)
                                                1.00 HZ
Are multiple values of the specular to multipath power     (39)
ratio to be tested? (Y/N):
                          N
ENTER THE SPECULAR-TO-MULTIPATH POWER RATIO (IN DB, I3):   (40)
                                                 100 DB
SET PARAMETERS FOR THE SECOND FADING CHANNEL:              (41)
TYPES OF FADING CHANNELS AVAILABLE:
 1: NO SPECULAR COMPONENT (RALEIGH FADING)
 2: SPECULAR COMPONENT, SHORTEST PATH
 3: SPECULAR COMPONENT, MEAN PATH
 INPUT TYPE OF CHANNEL:
                        2
ENTER THE MULTIPATH SPREAD TIME (IN MICROSECONDS, F9.2):   (42)
                                      500.00 MICROSECONDS
ENTER THE DOPPLER SPREAD BANDWIDTH (IN HERTZ, F7.2):       (43)
                                               1.00 HZ
Are multiple values of the specular to multipath power     (44)
ratio to be tested? (Y/N):
                          N
ENTER THE SPECULAR-TO-MULTIPATH POWER RATIO (IN DB, I3):   (45)
                                                 100 DB
```

In the next question,

```
Are multiple SNR values to be tested? Y-yes,N-no:          (46)
                                         Y
```

the user is asked whether multiple SNR values are to be tested. If the response is "Y" (yes), then questions 47.1 through 47.3 will appear asking the user to input the range of SNR's (in this case, the carrier to noise ratio) for the Gaussian noise in the mobile receiver. If multiple SNR values are not to be tested (response "N"), then the user will be asked to input only one SNR value.

Questions 47.1/47.3 would appear as follows:

```
Input the range of SNR values to be tested (in Db):          (47)
Input the initial value of SNR (-99 -- +99, I3):             (47.1)
                                              36 DB
Input the increment value (Ø1 -- 99, I2):                    (47.2)
                                  4 DB
Input the ending value of SNR (-99 -- +99, I3):              (47.3)
                                              4Ø DB
```

In the next question,

```
IS A SPACE DIVERSITY RECEIVER REQUIRED? (Y/N)                (48)
                                         Y
```

the user is asked whether or not a space diversity receiver is to be used. If it is present (response "Y"), then the user will be asked (next question) to input the duration of the decision period which is the duration of the lapse time before a decision is made to determine which receiver is receiving a stronger signal. If it is not present (response "N"), then the next question (49) will not displayed.

```
INPUT DURATION BETWEEN DECISION TIMES FOR THE S.D. RECEIVER
(F7.5, IN SECONDS)                                           (49)
                         Ø.ØØØ2ØSEC.
```

The next question is displayed as follows:

```
Input the approximate duration of simulation in seconds     (5Ø)
(Ø.Ø1 - 9.99, F4.2):
                      Ø.Ø1 SEC.
```

Here the user inputs the approximate duration of the input signal to be tested in seconds using the format F7.5. For now, the boundary imposed is from Ø.Ø1 seconds to 9.99 seconds (refer to section 4.1).

In the next question displayed,

```
Type of performance measurement available:                  (51)
  1. Compare recovered output signal to original input signal
  2. Measure output signal to noise ratio
Input type:
        1
```

the user is asked to input the type of performance to be measured. Under the current version, the user has the choice of choosing either to compare the recovered output signal to the original input signal (choice "1"), or (choice "2") to measure the output signal to noise ratio vs input signal to noise ratio (refer to section 4.2). If choice 2 is chosen, the user will be asked if he wishes that a plot be displayed of the input vs output SNR values. asked. However, if choice 1 is chosen, as is the case in this example, than the following will be the last question displayed:

DO YOU WANT OUTPUT TO BE PLOTTED? (52)

Y

Here the user has the option of having the output vs input signals plotted. If the response to this question is "Y" (yes), then following the printing of the input vs output signal values (for each respective SNR value), a graph will be plotted corresponding to these values. The maximum possible length of the graph is 2000 lines (per SNR value). If the response is "N" (no), then just the values without a graph will be printed.

A few lines of the resulting output are printed as follows:

Input signal	Output signal (No Noise)	Output signal (With Noise)
The SNR is 36.00 DB		
0.1000000E 01	-0.3008653E 02	0.6992087E 02
0.9972572E 00	-0.9639141E 03	0.2256493E 04
0.9890135E 00	-0.7375438E 04	0.1755339E 05
0.9752213E 00	-0.2662992E 05	0.6575075E 05
0.9557958E 00	-0.6205368E 05	0.1653216E 06
0.9306050E 00	-0.1081285E 06	0.3328434E 06
0.8994539E 00	-0.1487061E 06	0.5898719E 06
0.8620588E 00	-0.1609989E 06	0.9725955E 06
0.8180044E 00	-0.1277967E 06	0.1540994E 07
0.7666720E 00	-0.5651906E 05	0.2387130E 07
0.7071075E 00	-0.7818813E 03	0.3643070E 07
0.6377603E 00	0.7991531E 05	0.5487024E 07
0.5558942E 00	0.4918778E 06	0.8145275E 07
0.4559756E 00	0.1515125E 07	0.1188825E 08
0.3233112E 00	0.3496630E 07	0.1701875E 08
0.1490450E-02	0.6825587E 07	0.2384659E 08
-0.3233029E 00	0.1189424E 08	0.3265666E 08
-0.4559686E 00	0.1904904E 08	0.4366894E 08
-0.5558881E 00	0.2853454E 08	0.5699677E 08
-0.6377543E 00	0.4043526E 08	0.7258918E 08
-0.7071018E 00	0.5462040E 08	0.9018307E 08
	:	
	:	
	:	

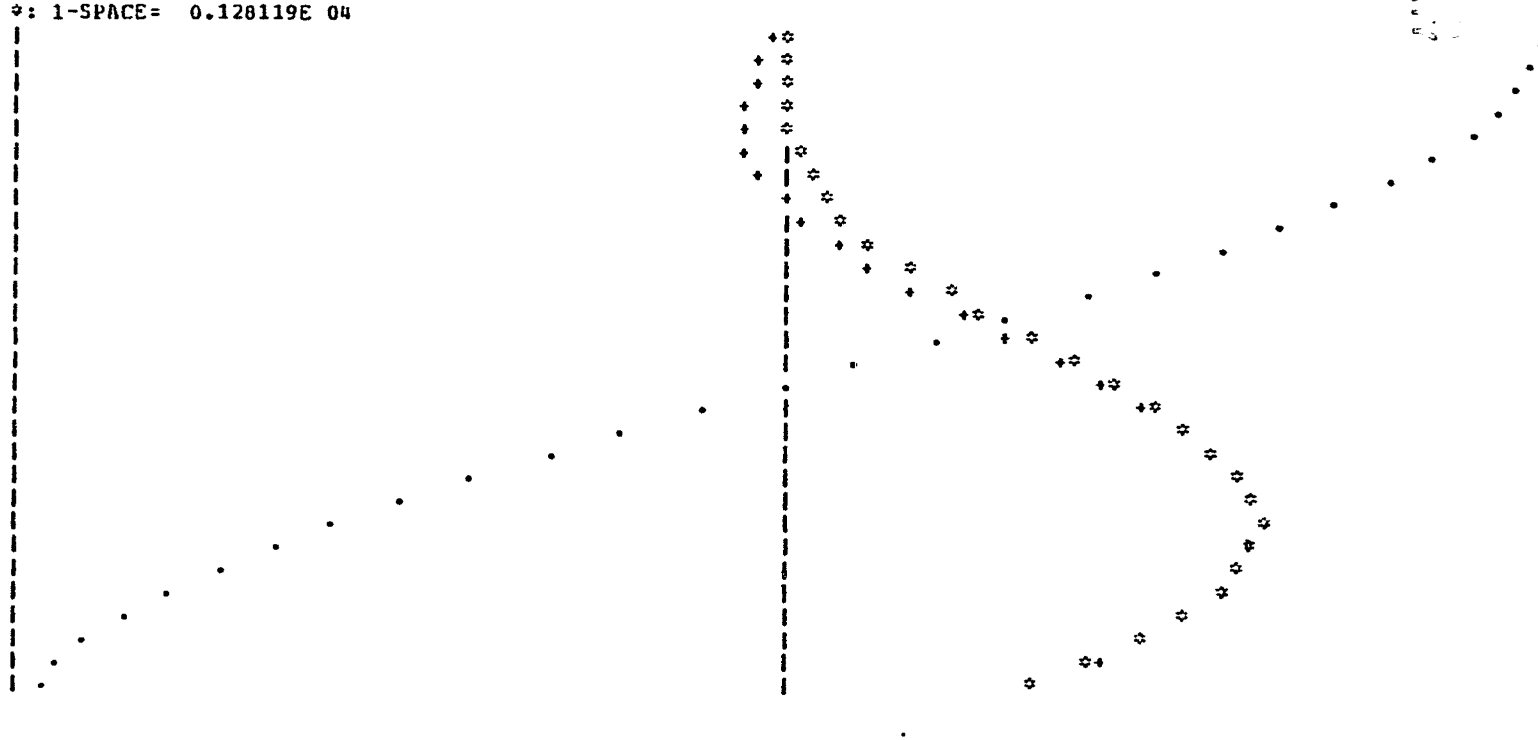
-0.8134990E 00	-0.3250146E 05	-0.3252382E 05
-0.7462617E 00	-0.3871931E 05	-0.3873486E 05
-0.6748396E 00	-0.4453807E 05	-0.4455445E 05
-0.5940157E 00	-0.4990534E 05	-0.4991791E 05
-0.5066984E 00	-0.5476577E 05	-0.5477025E 05
-0.4138190E 00	-0.5906239E 05	-0.5905626E 05
-0.3164213E 00	-0.6273980E 05	-0.6271593E 05
-0.2155438E 00	-0.6574794E 05	-0.6570694E 05
-0.1123206E 00	-0.6804550E 05	-0.6800881E 05
-0.7652316E-02	-0.6960200E 05	-0.6958081E 05
0.9668678E-01	-0.7039825E 05	-0.7038119E 05
0.2001823E 00	-0.7042663E 05	-0.7040781E 05
0.3014705E 00	-0.6968919E 05	-0.6967275E 05
0.3994715E 00	-0.6819650E 05	-0.6818431E 05
0.4930838E 00	-0.6596506E 05	-0.6595363E 05
0.5813091E 00	-0.6301504E 05	-0.6299994E 05
0.6631559E 00	-0.5936834E 05	-0.5935133E 05
0.7377512E 00	-0.5504795E 05	-0.5503618E 05
0.8042567E 00	-0.5008057E 05	-0.5008200E 05
0.8619632E 00	-0.4450350E 05	-0.4452383E 05
0.9102221E 00	-0.3837407E 05	-0.3841241E 05
0.9485188E 00	-0.3177484E 05	-0.3181984E 05
0.9764227E 00	-0.2480832E 05	-0.2484891E 05
0.9936365E 00	-0.1758397E 05	-0.1761883E 05
0.9999666E 00	-0.1020682E 05	-0.1023401E 05

.=INPUT SIGNAL,+=OUTPUT-NO NOISE,*=FADED OUTPUT

.: 1-SPACE= 0.181818E-01

+: 1-SPACE= 0.128063E 04

*: 1-SPACE= 0.128119E 04



5. Sample Runs

One of the biggest advantages of the present simulator is its ability to span over a range of inputs for the different devices, as opposed to only entering one value at a time as was the case in the previous simulation. This facility is illustrated in figure 1. In this particular example, 4 parameters are variables: the specular to multipath power ratio of the UHF downlink channel, the carrier to interference power ratio of the UHF downlink co-channel interfer, the phase values for the UHF downlink co-channel interferor, and the input signal to noise ratio of the Gaussian noise source. One can see from figure 1 that every possible permutation of the above values is exhibited. In this simulation run, a type one measurement is chosen with the plotting facility on. Thus the output is a list of the input vs. output values of the system, followed by its corresponding plot. One notes that a type one output exists for each of the possible permutations as mentioned above.

Figure 2 illustrates the above mentioned "looping" feature for a type 2 measurement. In this output, a type 2 measurement of the input vs. output SNR values and its corresponding plots are exhibited for every possible permutation of the 7- input parameters (columns) shown.

In figure 3, the output SNR values are being plotted as a function of the input SNR values for different values of the carrier to interference power ratio of the UHF uplink interference source. Again, the looping facility is exhibited here. One notes

from the output curves, that as the carrier to interference power ratio gets smaller, the output curves flatten out. At large values, the curves remain linear above threshold as expected.

Figure 4 illustrates the execution of a double hop system (scenario 2 in this case). One notes here that both an S-band and an UHF band uplink channel are set, as well as an S-band and an UHF band downlink channel.

6. Results

The results of the present simulator are divided into two sections; The analytical results (section 6.1), and the processed voice results (section 6.2). In both cases, tests are made using a single hop system (scenario 1).

6.1 Analytical Results

The system discussed can be seen to have the responses shown on various plots obtained for several different Rician channels over a single hop system (scenario 1).

We first analyzed a single hop system over a channel without fading or interference present as a function of the input SNR values. A pure sinusoid was used as input. The results can be seen in figure 6.1 (referenced from first report). Note that the results are analyzed for various combinations of signal processing stages. These results represent a pure FM system with white noise present.

We next simulated a single hop system over a Rician channel with no interference present, and analyzed the output vs input SNR values for various values of the specular-to-multipath component power ratios of the fading channel. The results are summarized in the plot of figure 6.2. First, we note that when the specular-to-multipath power ratio of the channel is 100 db, no

real effects of fading can be seen and the output vs input SNR curve remains a linear one as expected. An analysis of the various plots, however, does show that as the specular-to-multipath power ratio is decreased, a flattening out of the linear curve does occur and the effects of fading become increasingly destructive.

We next analyzed a single hop system over a Rician channel with no interference present, with and without a space diversity receiver present . The results are summarized in figure 6.3. One observes from this plot that there is a significant improvement with the space diversiy receiver on.

We next plotted the output signal-to-noise ratio as a function of the specular-to-multipath power ratio of the fading channel, with no other disturbances present. We started with a specular-to-multipath power ratio of -35 dB (practically Raleigh fading), and went all the way up to a specular-to-multipath power ratio of 100 dB. The results are summarized in figure 6.4. Here we noticed a threshold effect beginning at a specular-to-multipath power ratio of about +05 dB. The curve moves up very quickly in a linear fashion from 5 dB to 50 dB, and then flattens out to its maximum value.

Figure 6.5 considers the effects of interference on the output signal to noise ratio. One can observe from the plot that an interference source with a carrier to interference power ratio ranging from 100 dB all the way down to 20 dB has no major effect on the output performance. However, as one gets below 20 dB, a flattening out of the input vs. output SNR curve does occur above

threshold. As the carrier to interference power ratio is taken below 8 dB, the flattening out effects become very predominant and output performance starts getting poor. At 0 dB, the curve flattens out completely to about .5 dB (Threshold effect).

Figure 6.6 considers results obtained using scenario 2. In this plot we analyze the input vs. output SNR values of a double hop system assuming all four channels are Rician fading channels. The UHF uplink channel, the S-band downlink channel, the S-band uplink channel, and the UHF downlink channel are the channels which are considered. As one can see from the plot, various permutations of the 4 channels (specular to multipath power ratio of the fading channel is varied) are considered.

These are just a few of the vast number of results obtainable with this simulation. Section 5 contains various sample runs illustrating some of the various possible results obtainable.

6.2. Results: Voice

In addition to the analytical results, we were also able to use the simulation to process sampled voice and actually listen to it. In particular, the following tests were made on the voice:

First, we put the sampled voice through the simulation with no fading, interference, or thermal noise present, or in other words, "pure FM". The output voice sounded exactly the same as the input. We listened to the voice (still pure FM) with the pre-emphasis de-emphasis filters both off and on, and could here a slight improvement with the latter case. With the expander - compander on or off, difference in voice quality was to slight to be heard .

Next, with no other disturbances present, we listened to the voice as a function of the thermal noise power. Results could be summarized as follows:

Carrier-to-Noise Power Ratio (dB)	Speech Quality
+40	Excellent
+35	Excellent
+30	Excellent
+25	Excellent
+20	Excellent
+16	Very good
+14	Good
+12	Good (very light static)
+10	Fair (light crackling)
+08	Fair-Poor (crackling louder)
+06	Poor (crackling loud)
+03	Very Poor (Basically only crackling)
-02	No sign of voice (only loud crackling

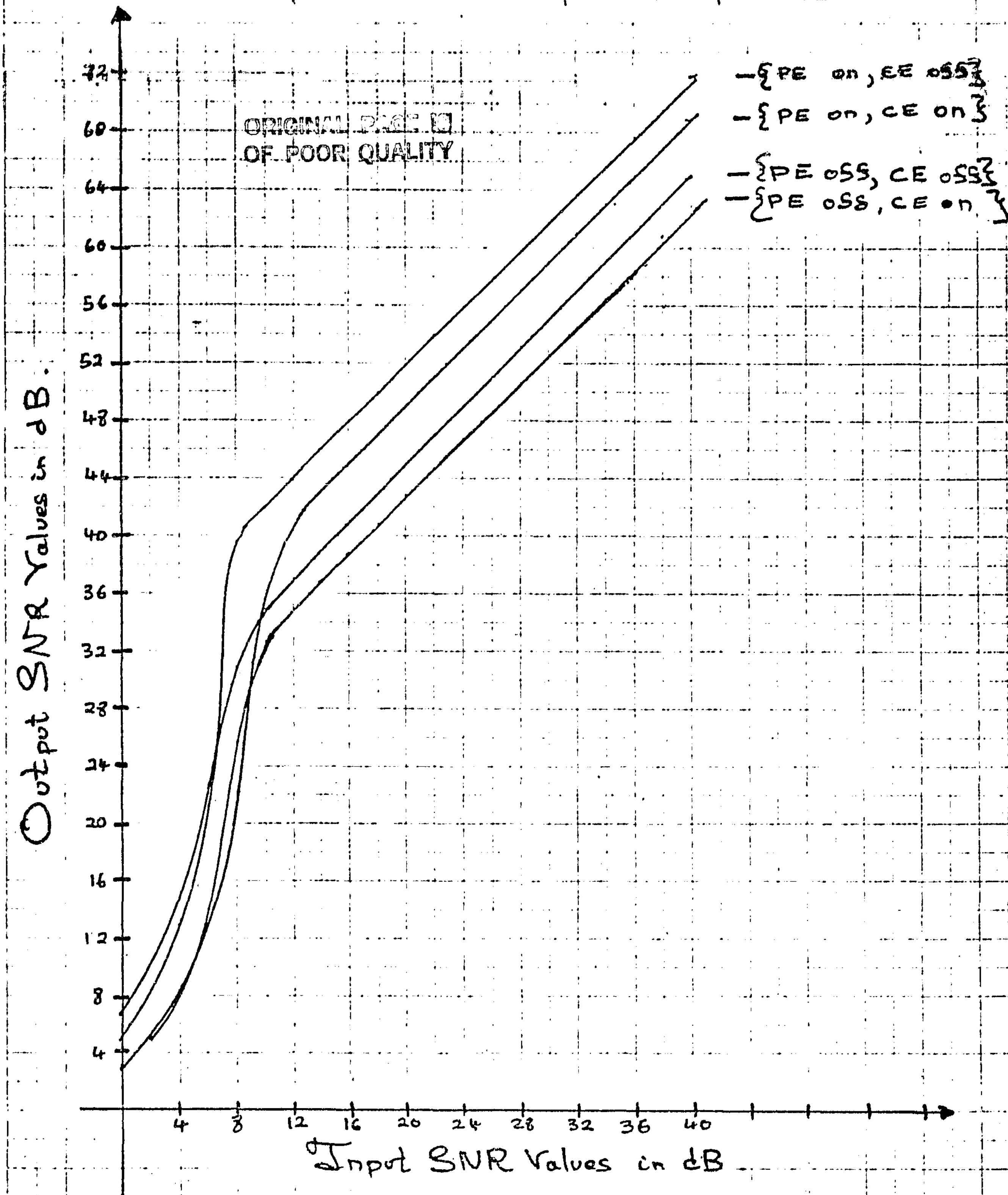
As the above indicates, the quality of voice went from excellent just above threshold, to poor just below threshold, consistent with our analytical results as well as theoretical results.

We then listened to the voice as a function of the specular-to-multipath power ratio (dB) of the fading channel (see sample run 5.1 for channel parameters), with no other disturbances present (input carrier-to-noise power ratio at +40dB). Within the range of specular-to-multipath power ratios from +6 dB and better, output voice quality was excellent. Within the range from -10 dB through +6 dB, voice quality was good (tonal characteristics of the voice were altered somewhat). Below -12 dB, voice quality was fair (tonal characteristics altered), with some crackling present.

The above examples are a few of the many possible tests on voice. Any of the 5 scenarios can be tested on the voice, with all possible parameter variations. (note that the above tests correspond to scenario 1).

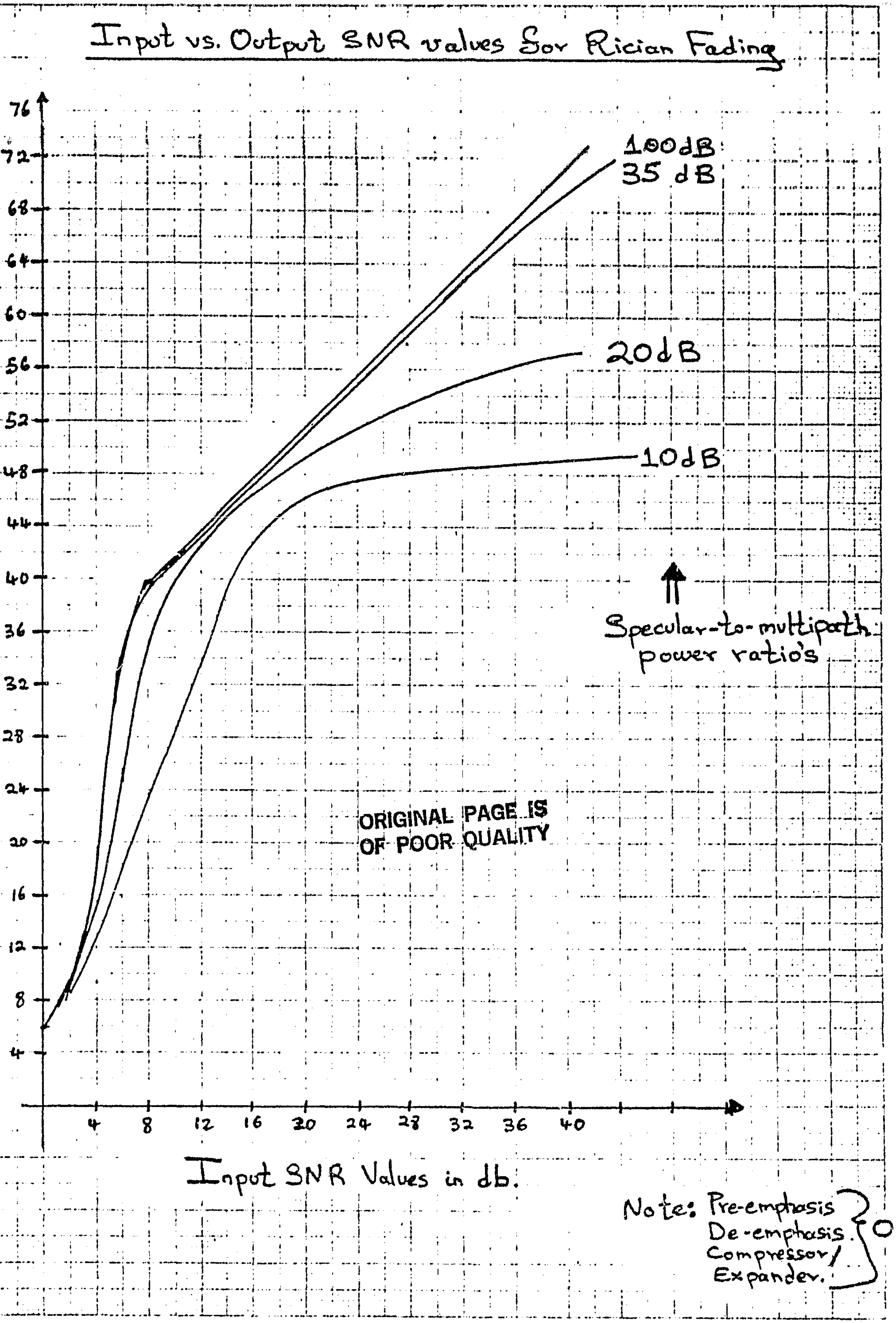
FIGURE 5.1

Input vs Output SNR Curves with and without Pre-emphasis/De-emphasis and/or Compressor/Expander



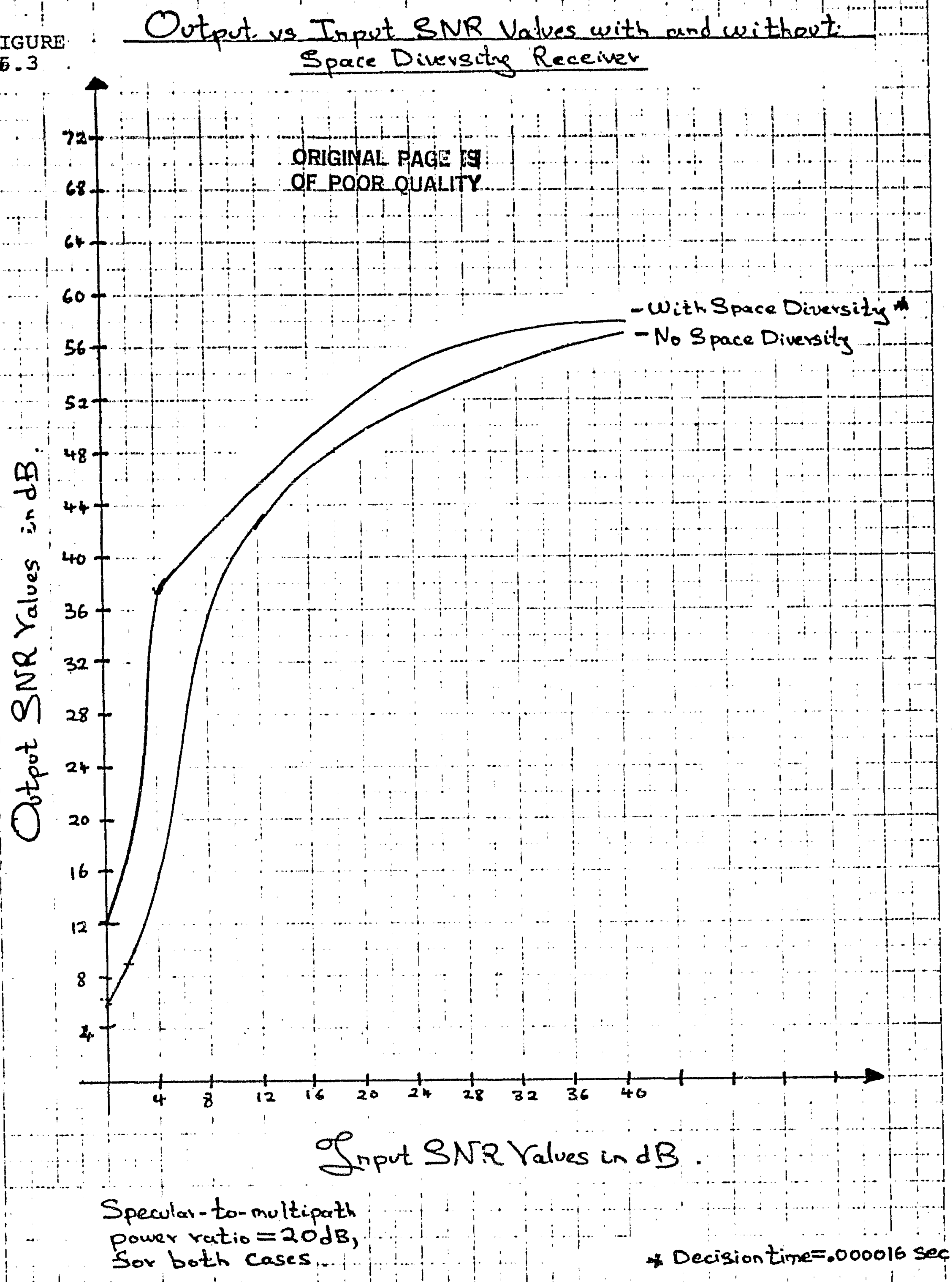
PE - Pre-emphasis-De-emphasis
CE - Compressor - Expander.

FIGURE 6.2



Input vs. Output SNR values for Rician Fading
Output SNR values in db.
76
72
68
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
4
8
12
16
20
24
28
32
36
40
Input SNR Values in db.
100dB
35 dB
20dB
10dB
Specular-to-multipath power ratio's
Note: Pre-emphasis De-emphasis Compressor/ Expander. O

FIGURE 5.3



Output vs Input SNR Values with and without Space Diversity Receiver
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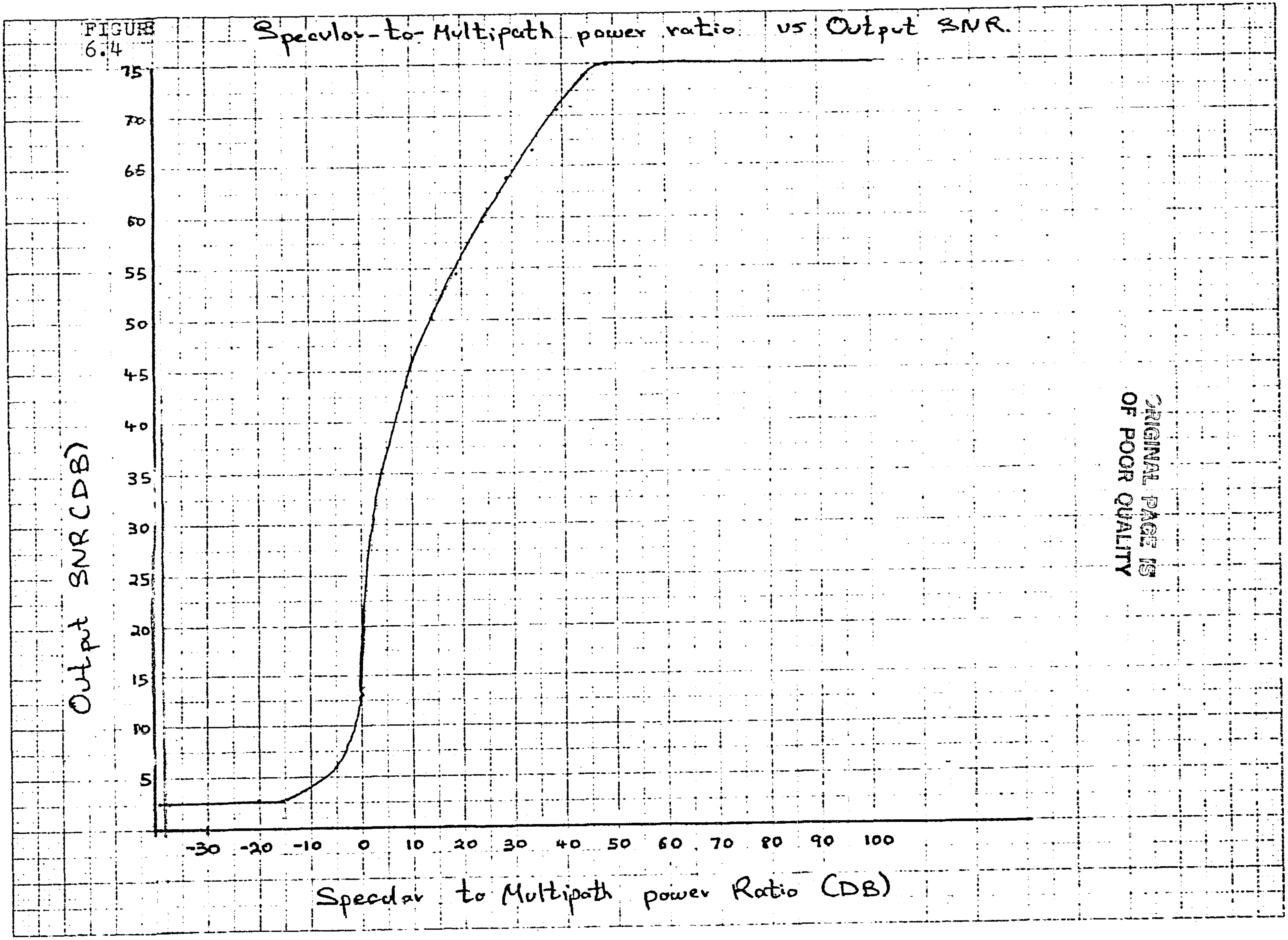
Output SNR Values in dB
72
68
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
4
8
12
16
20
24
28
32
36
40
Input SNR Values in dB.
-With Space Diversity *
-No Space Diversity
Specular-to-multipath power ratio = 20dB, for both cases.
* Decision time = .000016 sec

FIGURE 6.4



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6.5 Output vs Input SNR as a function of the Carrier-to-Interference Power Ratio

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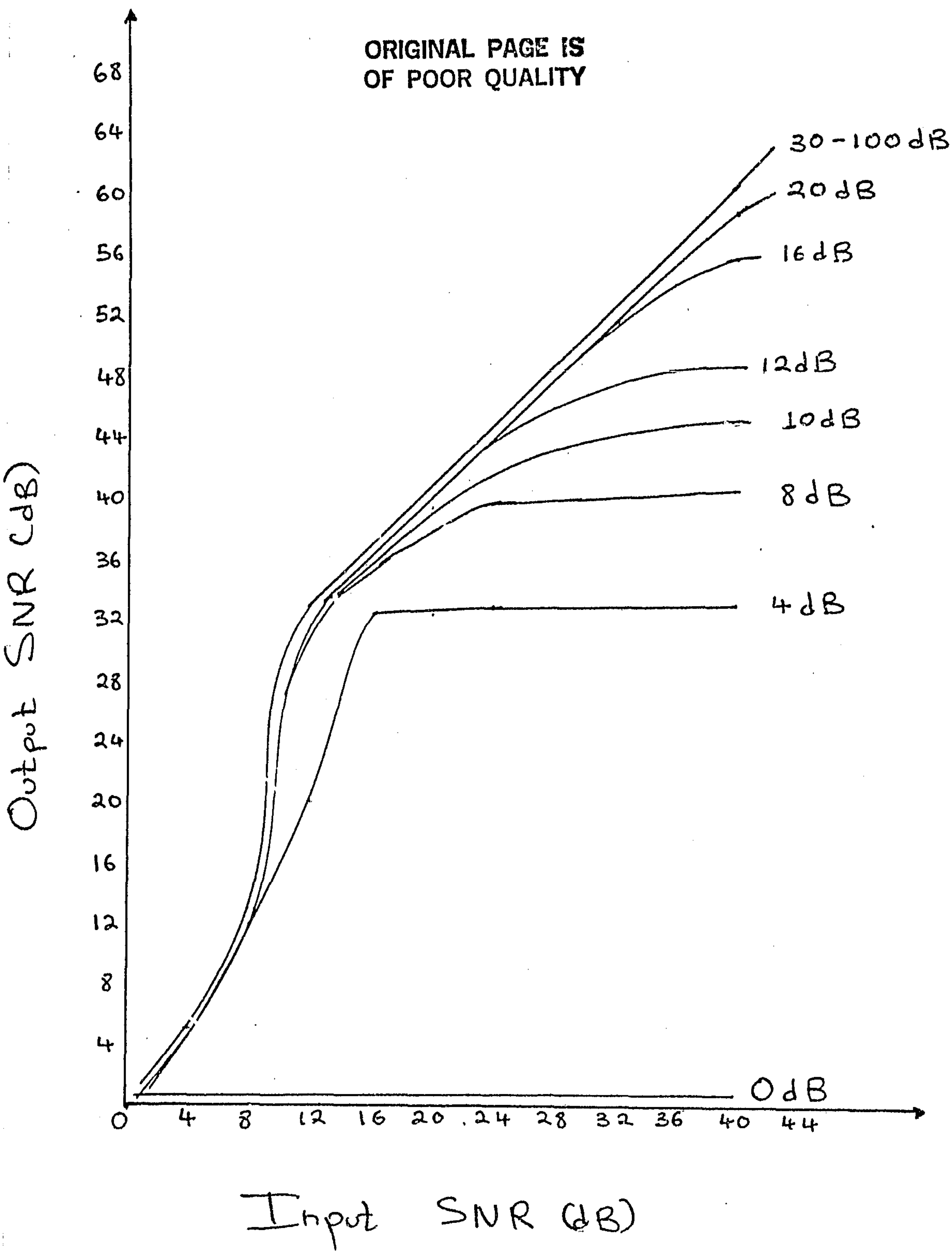
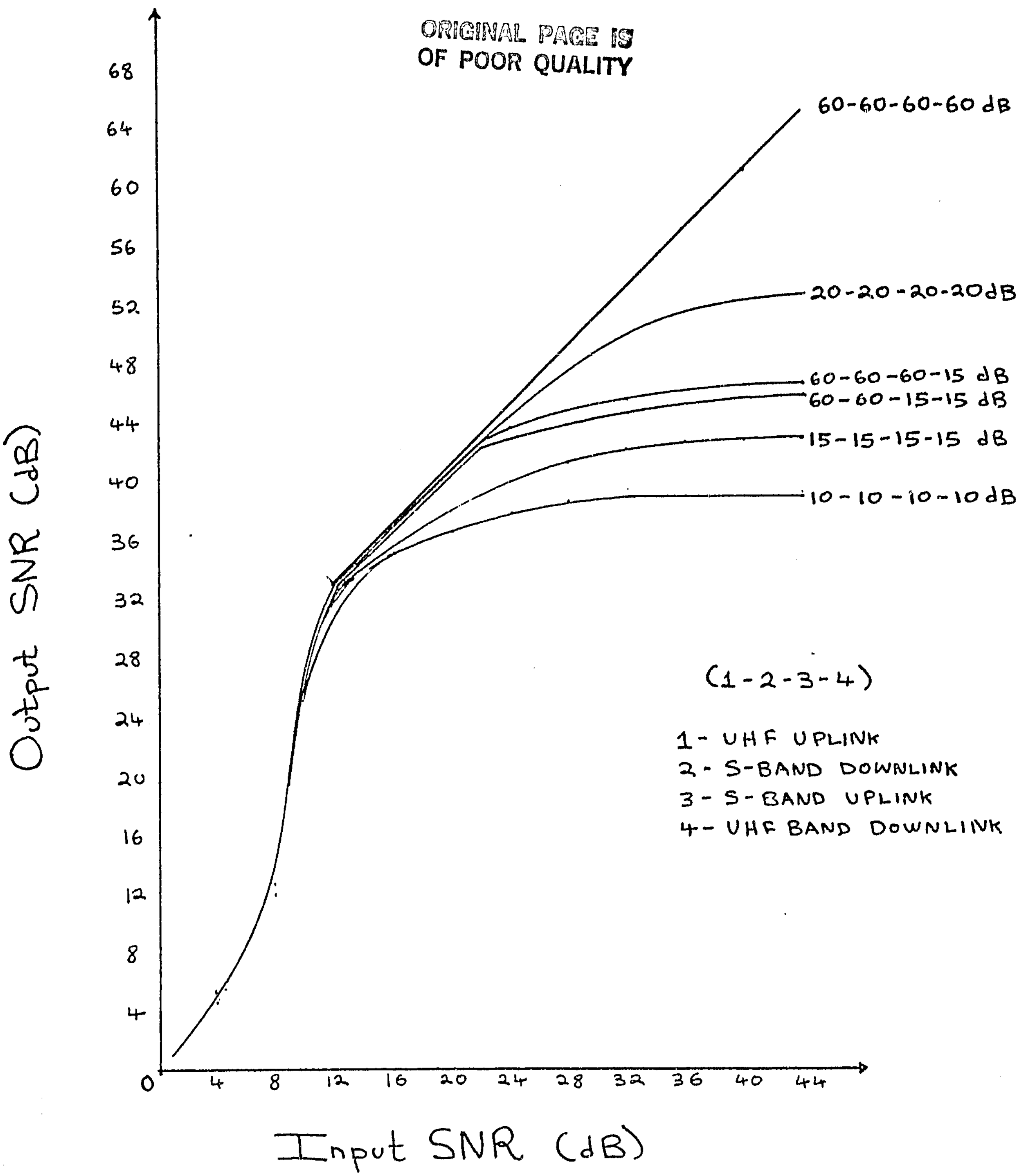


6.6 Multi-channel Performance of a Double Hop System (Scenario 2).



7. Proposed Research for the Forthcoming Year

Because of the present system's very modular structure, simulation of other modulation techniques over any one of the five scenarios can be done with relative ease. Since the simulation is designed in such a way that the inphase and quadrature phase components of the input signal are being passed through the components of the system in a parallel fashion, any type of modulation scheme which can be broken up into these components can be easily implemented. For example, the present simulator could be used to test the performance characteristics of duo-binary FM or tamed FM, both which use less bandwidth than standard FM.

At the same time, one could use the simulation to process voice using various modulation techniques to see which types produce the best subjective voice quality. In the report, we propose to construct a system to allow for simple testing of actual voice input. This system will allow for simple interfacing of voice input to the IBM system on which the actual simulation took place. We plan to build this device using a personal computer as the controller.

Also because of the systems modular structure, it would be possible test other types of components or noise sources.

```
Is this an online session? (Y/N)
                                                   N
TYPE OF CALL AVAILABLE:
1: M1->M2, rural mobile to rural mobile in same UHF beam
2: M1->M3, rural mobile to rural mobile in different UHF beam, in same S-band
3: M1->M4, rural mobile to rural mobile in different UHF beam, in different S-band
4: M1->FC1, rural mobile to fixed in same S-band beam
5: M1->FC2, rural mobile to fixed in different S-band beam
6: FC1->M1, fixed to rural mobile in same S-band beam
7: FC2->M1, fixed to rural mobile in different S-band beam
INPUT TYPE OF CALL TO BE SIMULATED:
                                            1
MODE OF CALL AVAILABLE:
1: M1->M2, hard wired transponder
2: M1->M2, direct switched transponder
3: M1->M2, indirect switched transponder
4: M1->G1->M2, double hop system
INPUT MODE OF CALL TO BE SIMULATED:
                                            1
FREQUENCY OF THE BASEBAND SIGNAL ( LESS THAN 3000 HZ. ) (IN HERTZ, F7.2):
                                                                            1000.00 HZ
NOTE : POWER OF THE BASEBAND SIGNAL HAS TO BE LESS OR EQUAL THAN .5 WATTS;
       SO THAT THE MAXIMUM INSTANTANEOUS FREQUENCY DEVIATION IS
       LESS OR EQUAL THAN 12000 HZ
POWER OF THE BASEBAND SIGNAL(IN WATTS, F7.2):
                                                      0.50 WATTS
THE CARRIER POWER (IN WATTS, F7.2):
                                              1.00 WATTS
THE FREQUENCY DEVIATION (IN HERTZ, F8.2): 12000 HZ.  (FIXED FOR NOW)
How many times the nyquist rate do you want the sampling frequency to be? (2 - 4, I1):
                                                                                         2
THE CARRIER FREQUENCY (IN HERTZ, F7.2):(NOT USED FOR NOW)
DO YOU WANT THE COMPRESSOR/EXPANDER IN?  Y-YES , N-NO :
                                                             N
DO YOU WANT THE PRE-EMPHASIS - DE-EMPHASIS FILTERS IN ?  Y-YES , N-NO :
                                                                          N
DO YOU WANT A CO-CHANNEL INTERFERER IN THE UPLINK? Y-YES,N-NO:
                                                                   N
IS FADING PRESENT IN THE UPLINK   CHANNEL? Y-YES,N-NO:
                                                            N
DO YOU WANT A CO-CHANNEL INTERFERER IN THE DOWNLINK? Y-YES,N-NO:
                                                                    Y
Are multiple values of the carrier to interference power
ratio to be tested? (Y/N):
                               Y
Input the range of values to be tested (in DB):
Input the initial value (-99 -- +99,I3) :
                                                  60DB
Input the increment value (01 -- 99,I3) :
                                                10DB
Input the final value (01 -- 99,I3) :
                                             60DB
Are multiple values of the interference phase values
to be tested? (Y/N):
                          Y
Input the range of values to be tested (in degrees):
Input the initial value (F6.2) :
                                           10.00DEGREES
```

```
Input the increment value (F6.2) :
                                   5.00DEGREES
Input the final value (F6.2) :
                              10.00DEGREES
IS FADING PRESENT IN THE DOWNLINK CHANNEL? Y-YES,N-NO:
                                                       Y
IS A SPACE DIVERSITY RECEIVER BEING USED? Y-YES,N-NO:
                                                      Y
IS THE INTERFERENCE FADED? Y-YES,N-NO:
                                       Y
THE DOWNLINK FADING CHANNEL IS PRESENT
SET PARAMETERS FOR FIRST FADING CHANNEL:
TYPES OF FADING CHANNELS AVAILABLE:
 1: NO SPECULAR COMPONENT (RALEIGH FADING)
 2: SPECULAR COMPONENT, SHORTEST PATH
 3: SPECULAR COMPONENT, MEAN PATH
 INPUT TYPE OF CHANNEL:
                       2
ENTER THE MULTIPATH SPREAD TIME (IN MICROSECONDS, F9.2):
                                                         500.00 MICROSECONDS
ENTER THE DOPPLER SPREAD BANDWIDTH (IN HERTZ, F7.2):
                                                     1.00 HZ
Are multiple values of the specular to multipath power
ratio to be tested? (Y/N):
                           Y
Input the range of values to be tested (in DB):
Input the initial value (-99 -- +99,I3):
                                        55DB
Input the incerment value (-99 -- +99,I2):
                                          10DB
Input the final value (01 -- 99,I2):
                                    55DB
SET PARAMETERS FOR THE SECOND FADING CHANNEL:
TYPES OF FADING CHANNELS AVAILABLE:
 1: NO SPECULAR COMPONENT (RALEIGH FADING)
 2: SPECULAR COMPONENT, SHORTEST PATH
 3: SPECULAR COMPONENT, MEAN PATH
 INPUT TYPE OF CHANNEL:
                       2
ENTER THE MULTIPATH SPREAD TIME (IN MICROSECONDS, F9.2):
                                                         500.00 MICROSECONDS
ENTER THE DOPPLER SPREAD BANDWIDTH (IN HERTZ, F7.2):
                                                     1.00 HZ
Are multiple values of the specular to multipath power
ratio to be tested? (Y/N):
                           Y
Input the range of values to be tested (in DB):
Input the initial value (-99 -- +99,I3):
                                        55DB
Input the incerment value (-99 -- +99,I2):
                                          10DB
Input the final value (01 -- 99,I2):
                                    55DB
Are multiple SNR values to be tested? Y-yes,N-no:
                                                 Y
Input the range of SNR values to be tested (in Db):
Input the initial value of SNR (-99 -- +99, I3):
                                               36 DB
Input the increment value (01 -- 99, I2):
                                         4 DB
```

```
Input the ending value of SNR (-99 -- +99, I3):
                                                          40 DB
IS A SPACE DIVERSITY RECEIVER REQUIRED? (Y/N)
                                                         Y
INPUT DURATION BETWEEN DECISION TIMES FOR THE S.D. RECEIVER (F7.5, IN SECONDS)
                                                                                 0.00020SEC.
Input the approximate duration of simulation in seconds (0.01 - 9.59, F4.2):
                                                                                    0.01 SEC.
Type of performance measurement available:
  1. Compare recovered output signal to original input signal
  2. Measure output si  al to noise ratio
Input type:
         1
DO YOU WANT OUTPUT TO BE PLOTTED?
                                                 Y
 1-Specular to multipath power ratio- Downlink Channel
 2-Carrier to interference power ratios- UHF Downlink Channel
 3-Phase values of interference- UHF Downlink Channel
 4-Input SNR Value
   1        2        3        4
------   ------   ------   ------------
 55.00    50.00   10.00    36.0000000
Input signal        Output signal (No Noise)         Output signal (With Noise)
____________        ________________________         __________________________
 0.1000000E 01        -0.3546265E 03                    0.9127492E 02
 0.9945219E 00        -0.1308870E 04                    0.3039616E 03
 0.9781477E 00        -0.2297429E 04                    0.6371396E 03
 0.9510567E 00        -0.2868278E 04                    0.9103672E 03
 0.9135456E 00        -0.2998826E 04                    0.1258146E 04
 0.8660256E 00        -0.2613447E 04                    0.1859902E 04
 0.8090173E 00        -0.1618976E 04                    0.2839659E 04
 0.7431453E 00         0.4053467E 02                    0.4315346E 04
 0.6691312E 00         0.2359897E 04                    0.6330977E 04
 0.5877859E 00         0.5289641E 04                    0.8883230E 04
 0.5000019E 00         0.8754652E 04                    0.1193763E 05
 0.4067382E 00         0.1265577E 05                    0.1541877E 05
 0.3090183E 00         0.1686925E 05                    0.1921204E 05
 0.2079136E 00         0.2125362E 05                    0.2318742E 05
 0.1045309E 00         0.2565789E 05                    0.2720433E 05
 0.2221441E-05         0.2992696E 05                    0.3111771E 05
-0.1045247E 00         0.3390678E 05                    0.3478890E 05
-0.2079074E 00         0.3745015E 05                    0.3807883E 05
-0.3090113E 00         0.4042305E 05                    0.4084572E 05
-0.4067307E 00         0.4270941E 05                    0.4235870E 05
-0.4999930E 00         0.4421439E 05                    0.4431964E 05
-0.5877774E 00         0.4486550E 05                    0.4486210E 05
-0.6691231E 00         0.4461211E 05                    0.4453346E 05
-0.7431371E 00         0.4342422E 05                    0.4329643E 05
-0.8090098E 00         0.4129246E 05                    0.4113549E 05
-0.8660184E 00         0.3823110E 05                    0.3805855E 05
-0.9135392E 00         0.3428400E 05                    0.3410566E 05
-0.9510516E 00         0.2952932E 05                    0.2935406E 05
-0.9781449E 00         0.2407629E 05                    0.2391016E 05
-0.9945199E 00         0.1805300E 05                    0.1789995E 05
-0.1000000E 01         0.1159213E 05                    0.1145747E 05
-0.9945242E 00         0.4822430E 04                    0.4713137E 04
-0.9781522E 00        -0.2133279E 04                   -0.2213715E 04
-0.9510638E 00        -0.9164684E 04                   -0.9219867E 04
-0.9135556E 00        -0.1615573E 05                   -0.1621178E 05
-0.8660381E 00        -0.2304518E 05                   -0.2309281E 05
```

4

180.	-0.8090329E 00	-0.2972033E 05	-0.2976236E 05
181.	-0.7431634E 00	-0.3611538E 05	-0.3613345E 05
182.	-0.6691524E 00	-0.4215837E 05	-0.4215495E 05
183.	-0.5878101E 00	-0.4777842E 05	-0.4777386E 05
184.	-0.5000271E 00	-0.5290458E 05	-0.5290686E 05
185.	-0.4067667E 00	-0.5746700E 05	-0.5748503E 05
186.	-0.3090497E 00	-0.6139990E 05	-0.6144706E 05
187.	-0.2079459E 00	-0.6464539E 05	-0.6471502E 05
188.	-0.1045648E 00	-0.6715650E 05	-0.6722169E 05
189.	-0.3718153E-04	-0.6889931E 05	-0.6893938E 05
190.	0.1044899E 00	-0.6985300E 05	-0.6986744E 05
191.	0.2078722E 00	-0.7000956E 05	-0.7000250E 05
192.	0.3089781E 00	-0.6937213E 05	-0.6934825E 05
193.	0.4066978E 00	-0.6795288E 05	-0.6792225E 05
194.	0.4999627E 00	-0.6577056E 05	-0.6574175E 05
195.	0.5877492E 00	-0.6284800E 05	-0.6282023E 05
196.	0.6690964E 00	-0.5920971E 05	-0.5918269E 05
197.	0.7431136E 00	-0.5488154E 05	-0.5486558E 05
198.	0.8089886E 00	-0.4989328E 05	-0.4989481E 05
199.	0.8660005E 00	-0.4428588E 05	-0.4429971E 05
200.	0.9135250E 00	-0.3812075E 05	-0.3813838E 05
201.	0.9510405E 00	-0.3148445E 05	-0.3150355E 05
202.	0.9781367E 00	-0.2448261E 05	-0.2451255E 05
203.	0.9945163E 00	-0.1722654E 05	-0.1727591E 05
204.	0.1000000E 01	-0.9822348E 04	-0.9886230E 04
205.	0.9945278E 00	-0.2367284E 04	-0.2432360E 04
206.	0.9781597E 00	0.5050090E 04	0.4999566E 04
207.	0.9510749E 00	0.1235017E 05	0.1232246E 05
208.	0.9135698E 00	0.1945291E 05	0.1946250E 05
209.	0.8660561E 00	0.2632707E 05	0.2635513E 05
210.	0.8090535E 00	0.3288803E 05	0.3292590E 05
211.	0.7431874E 00	0.3909482E 05	0.3913027E 05
212.	0.6691790E 00	0.4489691E 05	0.4493780E 05
213.	0.5878384E 00	0.5024172E 05	0.5028242E 05
214.	0.5000582E 00	0.5507376E 05	0.5509581E 05
215.	0.4067986E 00	0.5933614E 05	0.5933974E 05
216.	0.3090830E 00	0.6297383E 05	0.6297384E 05
217.	0.2079811E 00	0.6593744E 05	0.6593544E 05
218.	0.1045996E 00	0.6818663E 05	0.6817588E 05
219.	0.7309525E-04	0.6969169E 05	0.6968163E 05
220.	-0.1044542E 00	0.7043463E 05	0.7043706E 05
221.	-0.2078381E 00	0.7040856E 05	0.7041113E 05
222.	-0.3099439E 00	0.6961644E 05	0.6960206E 05
223.	-0.4066659E 00	0.6806944E 05	0.6804369E 05
224.	-0.4999316E 00	0.6578450E 05	0.6576169E 05
225.	-0.5877201E 00	0.6278211E 05	0.6276499E 05
226.	-0.6690704E 00	0.5908429E 05	0.5906898E 05
227.	-0.7430896E 00	0.5471427E 05	0.5470021E 05
228.	-0.8089681E 00	0.4969926E 05	0.4968748E 05
229.	-0.8659830E 00	0.4407779E 05	0.4406672E 05
230.	-0.9135104E 00	0.3790904E 05	0.3789540E 05
231.	-0.9510297E 00	0.3127739E 05	0.3126080E 05
232.	-0.9781293E 00	0.2428645E 05	0.2427244E 05
233.	-0.9945125E 00	0.1704566E 05	0.1704160E 05
234.	-0.1000000E 01	0.9659547E 04	0.9667125E 04
235.	-0.9945316E 00	0.2224056E 04	0.2236339E 04
236.	-0.9781669E 00	-0.5173293E 04	-0.5167508E 04
237.	-0.9510857E 00	-0.1245371E 05	-0.1246022E 05
238.	-0.9135844E 00	-0.1954774E 05	-0.1956504E 05
239.	-0.8660736E 00	-0.2639459E 05	-0.2641453E 05

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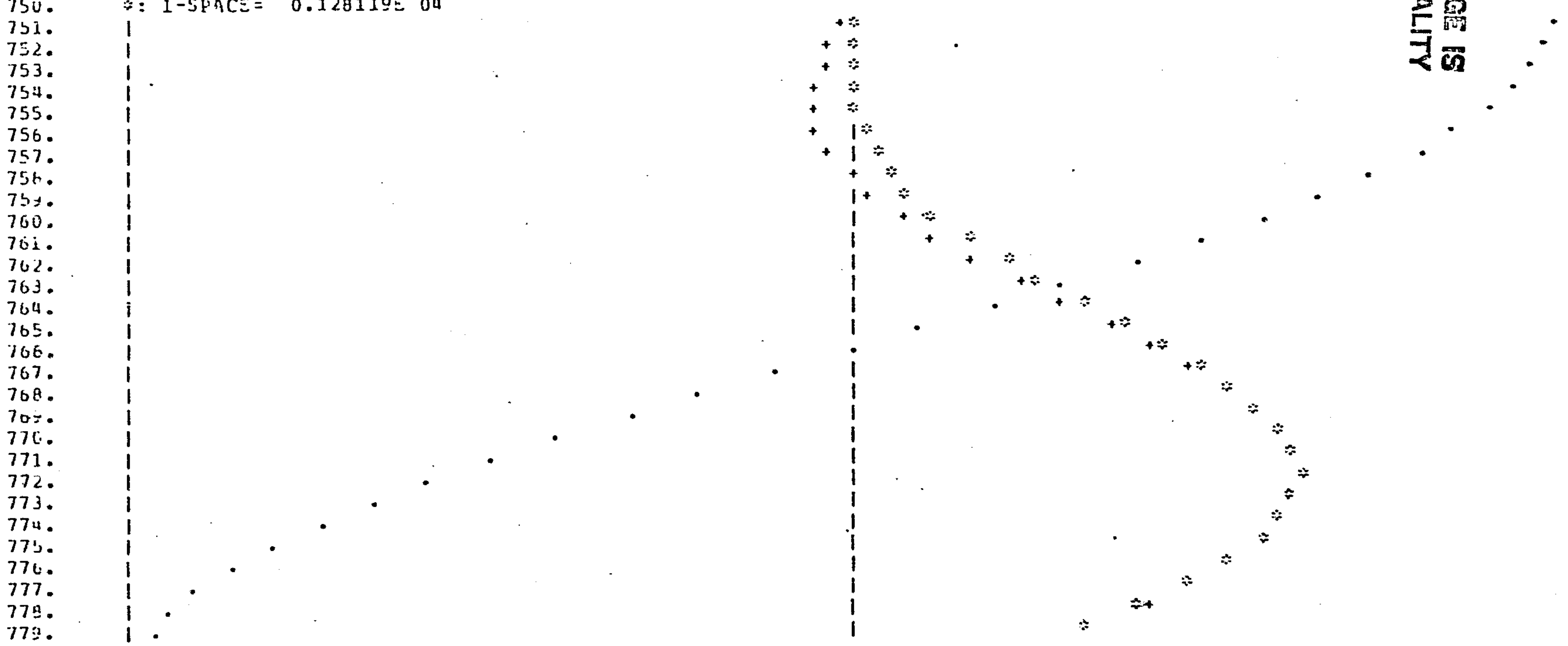
720.	-0.8134990E 00	-0.3250146E 05	-0.3252382E 05
721.	-0.7462617E 00	-0.3871931E 05	-0.3873486E 05
722.	-0.6748396E 00	-0.4453807E 05	-0.4455445E 05
723.	-0.5940157E 00	-0.4990534E 05	-0.4991791E 05
724.	-0.5066984E 00	-0.5476577E 05	-0.5477025E 05
725.	-0.4138190E 00	-0.5906239E 05	-0.5905626E 05
726.	-0.3164213E 00	-0.6273980E 05	-0.6271593E 05
727.	-0.2155436E 00	-0.6574794E 05	-0.6570694E 05
728.	-0.1123206E 00	-0.6804550E 05	-0.6800881E 05
729.	-0.7652316E-02	-0.6960200E 05	-0.6958081E 05
730.	0.9668676E-01	-0.7039825E 05	-0.7038119E 05
731.	0.2001823E 00	-0.7042663E 05	-0.7040781E 05
732.	0.3014705E 00	-0.6968919E 05	-0.6967275E 05
733.	0.3994715E 00	-0.6819650E 05	-0.6818431E 05
734.	0.4930838E 00	-0.6596506E 05	-0.6595363E 05
735.	0.5813091E 00	-0.6301504E 05	-0.6299994E 05
736.	0.6631559E 00	-0.5936834E 05	-0.5935133E 05
737.	0.7377512E 00	-0.5504795E 05	-0.5503618E 05
738.	0.8042567E 00	-0.5008057E 05	-0.5008200E 05
739.	0.8619632E 00	-0.4450350E 05	-0.4452383E 05
740.	0.9102221E 00	-0.3837407E 05	-0.3841241E 05
741.	0.9485188E 00	-0.3177484E 05	-0.3181984E 05
742.	0.9764227E 00	-0.2480832E 05	-0.2484891E 05
743.	0.9936365E 00	-0.1758397E 05	-0.1761683E 05
744.	0.9999666E 00	-0.1020682E 05	-0.1023401E 05

745. --
746. ==
747. .=INPUT SIGNAL,+=OUTPUT-NO NOISE,*=FADED OUTPUT
748. .: 1-SPACE= 0.181818E-01
749. +: 1-SPACE= 0.128063E 04
750. *: 1-SPACE= 0.128119E 04



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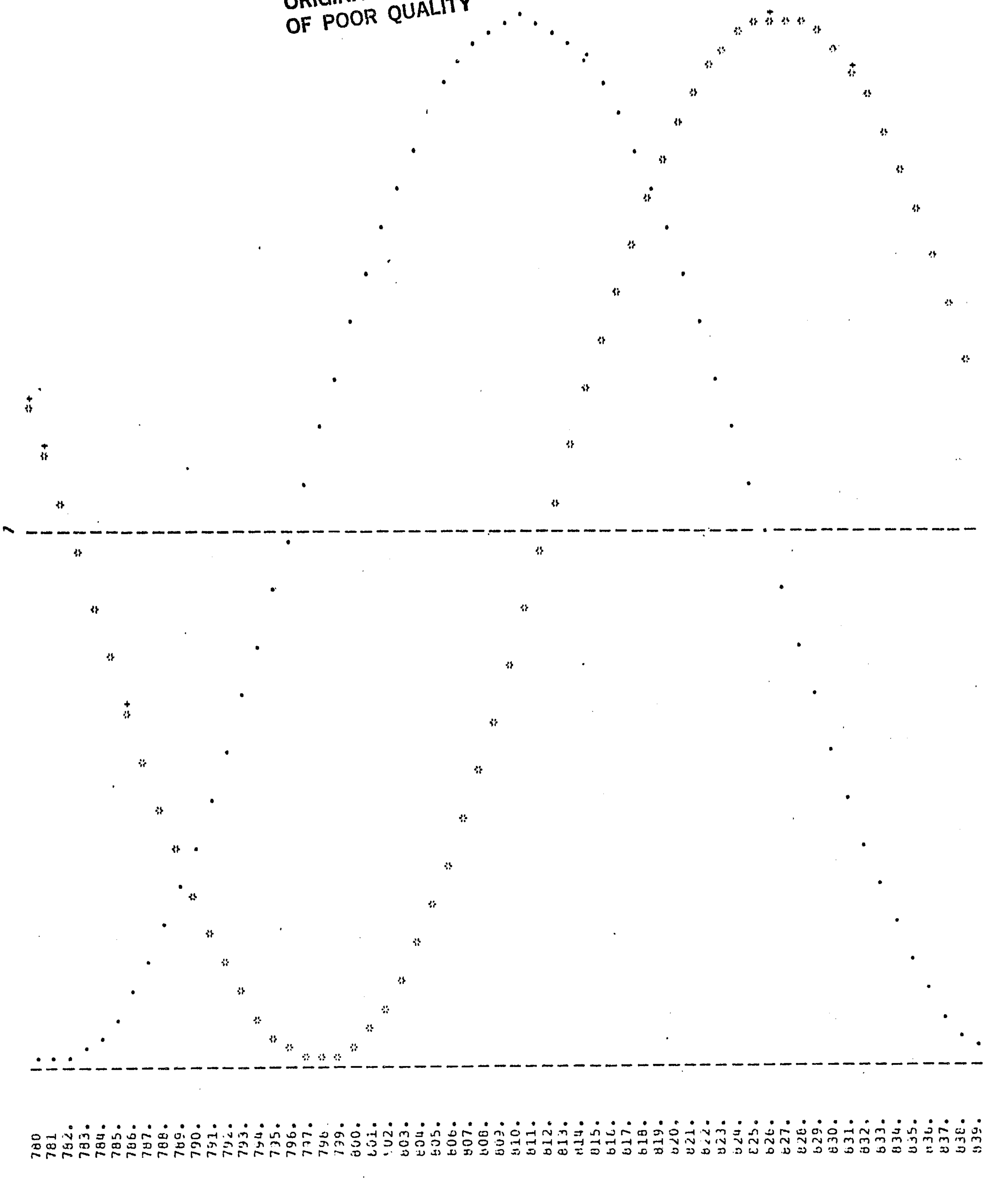

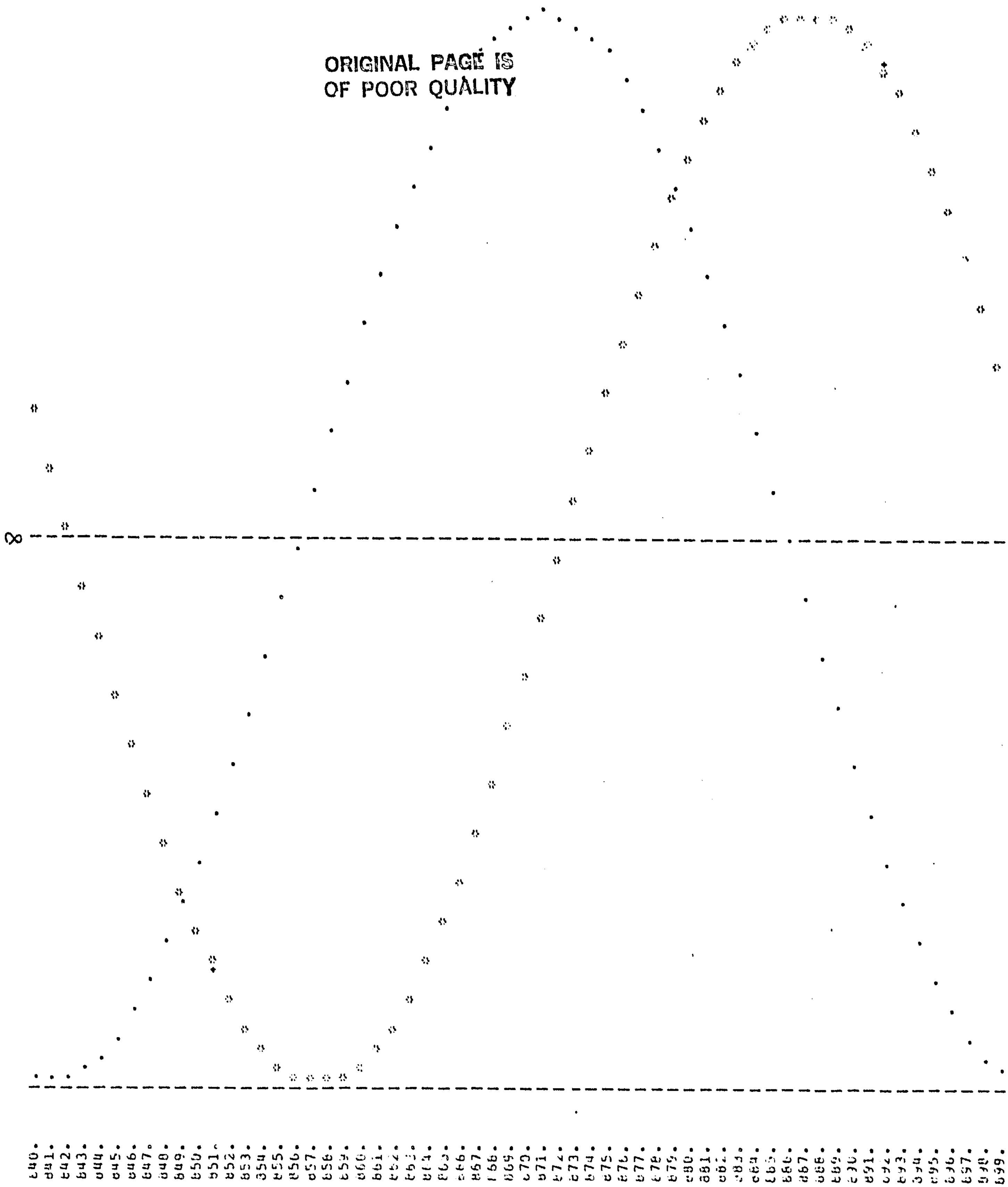

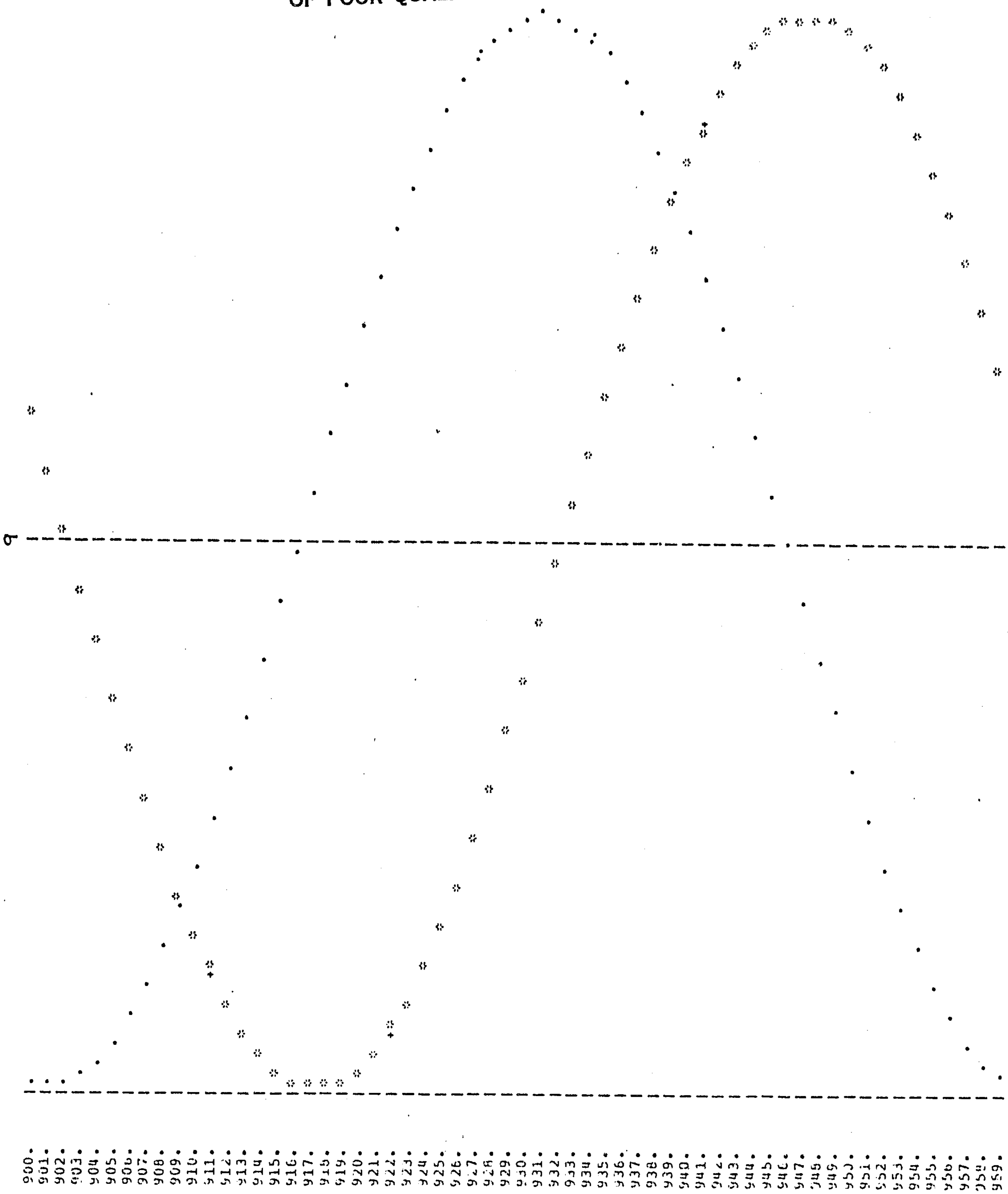

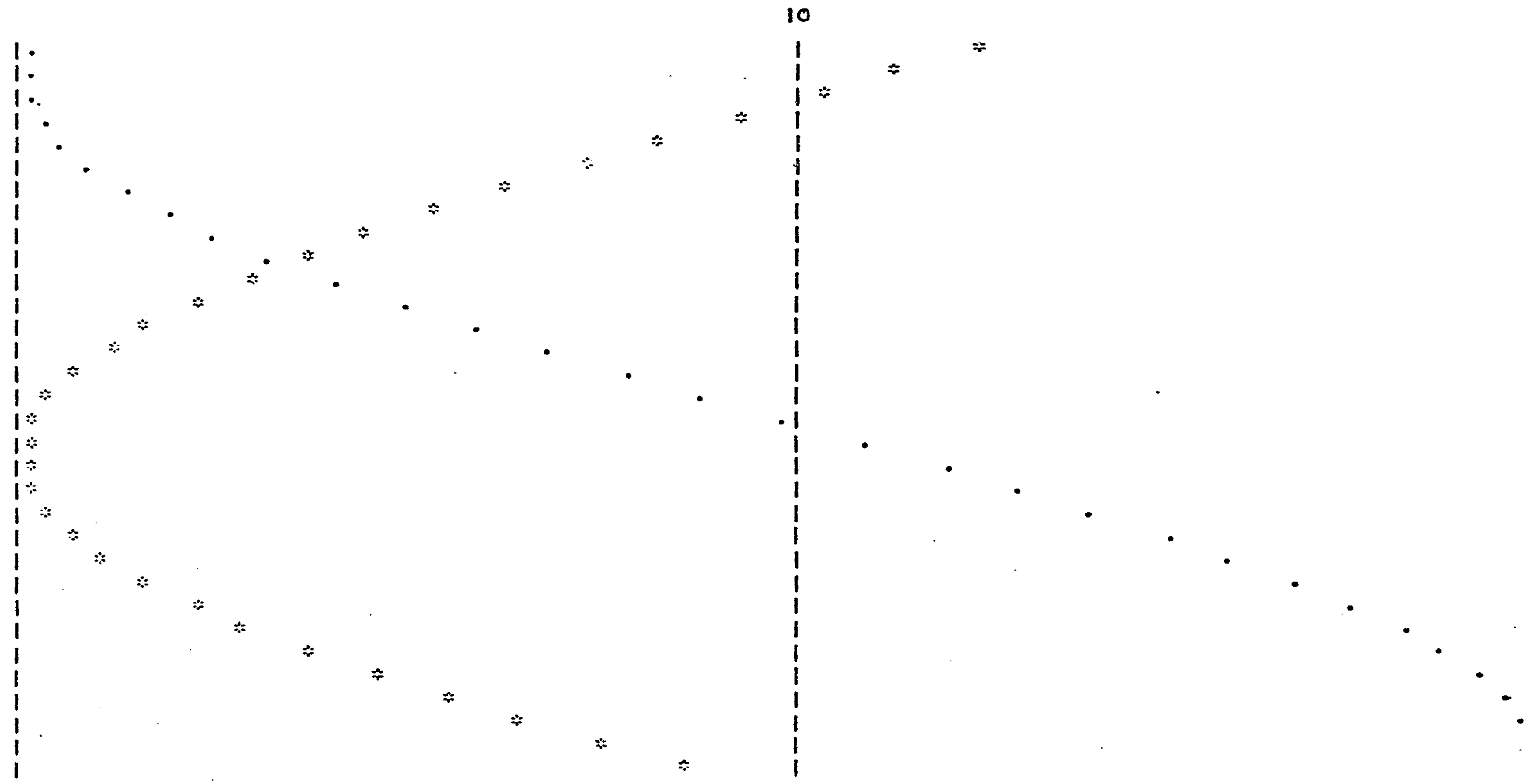

1	2	3	4
55.00	60.00	10.00	40.0000000

Input signal	Output signal (No Noise)	Output signal (With Noise)
0.1000000E 01	-0.2772237E 04	-0.2795974E 04
0.9945219E 00	0.4838637E 04	0.4803941E 04
0.9781477E 00	0.1286013E 05	0.1282084E 05
0.9510567E 00	0.2100996E 05	0.2098813E 05
0.9135456E 00	0.2873141E 05	0.2873206E 05
0.8660256E 00	0.3586253E 05	0.3588194E 05
0.8090173E 00	0.4242826E 05	0.4245813E 05
0.7431453E 00	0.4839245E 05	0.4841986E 05
0.6691312E 00	0.5374292E 05	0.5376315E 05
0.5877859E 00	0.5848212E 05	0.5849372E 05
0.5000010E 00	0.6259657E 05	0.6260185E 05
0.4067382E 00	0.6605913E 05	0.6607675E 05
0.3090183E 00	0.6888213E 05	0.6889513E 05
0.2079136E 00	0.7101725E 05	0.7103463E 05
0.1045300E 00	0.7245975E 05	0.7248288E 05
0.2221441E-05	0.7320056E 05	0.7322319E 05
-0.1045247E 00	0.7323656E 05	0.7324936E 05
-0.2079074E 00	0.7257094E 05	0.7257475E 05
-0.3090113E 00	0.7121225E 05	0.7121025E 05
-0.4067307E 00	0.6917375E 05	0.6916425E 05
-0.4999930E 00	0.6647131E 05	0.6645313E 05
-0.5877774E 00	0.6312226E 05	0.6309784E 05

II

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1920.   -0.6636401E 00    0.5934346E 05          0.5934452E 05
1921.   -0.7381880E 00    0.5501693E 05          0.5501455E 05
1922.   -0.8046411E 00    0.5004760E 05          0.5003273E 05
1923.   -0.8622911E 00    0.4446686E 05          0.4444214E 05
1924.   -0.9104899E 00    0.3833419E 05          0.3830386E 05
1925.   -0.9487236E 00    0.3173232E 05          0.3170295E 05
1926.   -0.9765623E 00    0.2476386E 05          0.2474108E 05
1927.   -0.9937092E 00    0.1753824E 05          0.1752593E 05
1928.   -0.9999716E 00    0.1016046E 05          0.1015360E 05
1929.   -0.9952828E 00    0.2727003E 04          0.2720426E 04
1930.   -0.9796954E 00   -0.4674066E 04         -0.4675148E 04
1931.   -0.9533756E 00   -0.1196336E 05         -0.1194940E 05
1932.   -0.9166194E 00   -0.1907083E 05         -0.1904743E 05
1933.   -0.8698184E 00   -0.2593518E 05         -0.2591674E 05
1934.   -0.8134990E 00   -0.3250172E 05         -0.3246980E 05
1935.   -0.7482617E 00   -0.3871952E 05         -0.3870435E 05
1936.   -0.6748396E 00   -0.4453823E 05         -0.4451641E 05
1937.   -0.5940157E 00   -0.4993544E 05         -0.4988629E 05
1938.   -0.5066984E 00   -0.5476582E 05         -0.5475410E 05
1939.   -0.4138190E 00   -0.5906240E 05         -0.5905006E 05
1940.   -0.3164213E 00   -0.6273977E 05         -0.6272255E 05
1941.   -0.2155439E 00   -0.6574788E 05         -0.6573019E 05
1942.   -0.1123206E 00   -0.6804544E 05         -0.6803163E 05
1943.   -0.7852316E-02   -0.6960188E 05         -0.6959406E 05
1944.    0.9668678E-01   -0.7039819E 05         -0.7039825E 05
1945.    0.2001823E 00   -0.7042656E 05         -0.7043138E 05
1946.    0.3014705E 00   -0.6968913E 05         -0.6969200E 05
1947.    0.3994715E 00   -0.6819644E 05         -0.6819775E 05
1948.    0.4930638E 00   -0.6596494E 05         -0.6597188E 05
1949.    0.5813091E 00   -0.6301495E 05         -0.6302998E 05
1950.    0.6631559E 00   -0.5935823E 05         -0.5938573E 05
1951.    0.7377512E 00   -0.5504783E 05         -0.5506212E 05
1952.    0.8042567E 00   -0.5008924E 05         -0.5008956E 05
1953.    0.8619632E 00   -0.4450338E 05         -0.4450699E 05
1954.    0.9102221E 00   -0.3837396E 05         -0.3837339E 05
1955.    0.9485186E 00   -0.3177475E 05         -0.3177151E 05
1956.    0.9764227E 00   -0.2480826E 05         -0.2480193E 05
1957.    0.9936365E 00   -0.1758392E 05         -0.1757286E 05
1958.    0.9999666E 00   -0.1020677E 05         -0.1019132E 05
1959.   -------------------------------------------------
1960.   =================================================
1961.   .=INPUT SIGNAL,+=OUTPUT-NO NOISE,*=FADED OUTPUT
1962.   .: 1-SPACE=  0.181818E-01
1963.   +: 1-SPACE=  0.133157E 04
1964.   *: 1-SPACE=  0.133161E 04
1965.   |
1966.   |
1967.   |
1968.   |
1969.   |
1970.   |
1971.   |
1972.   |
1973.   |
1974.   |
1975.   |
1976.   |
1977.   |
1978.   |
1979.   |
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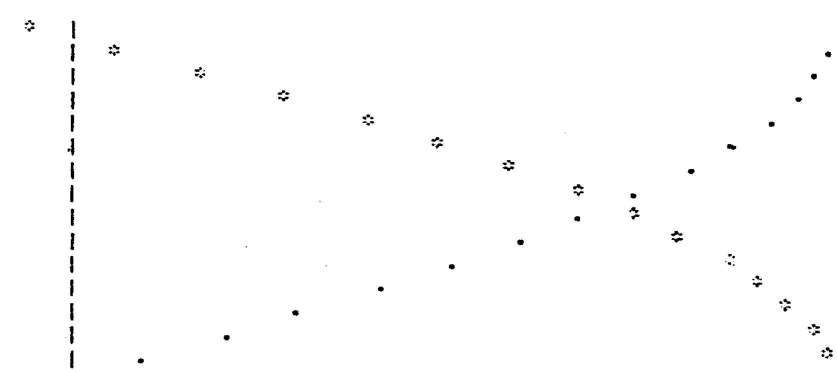

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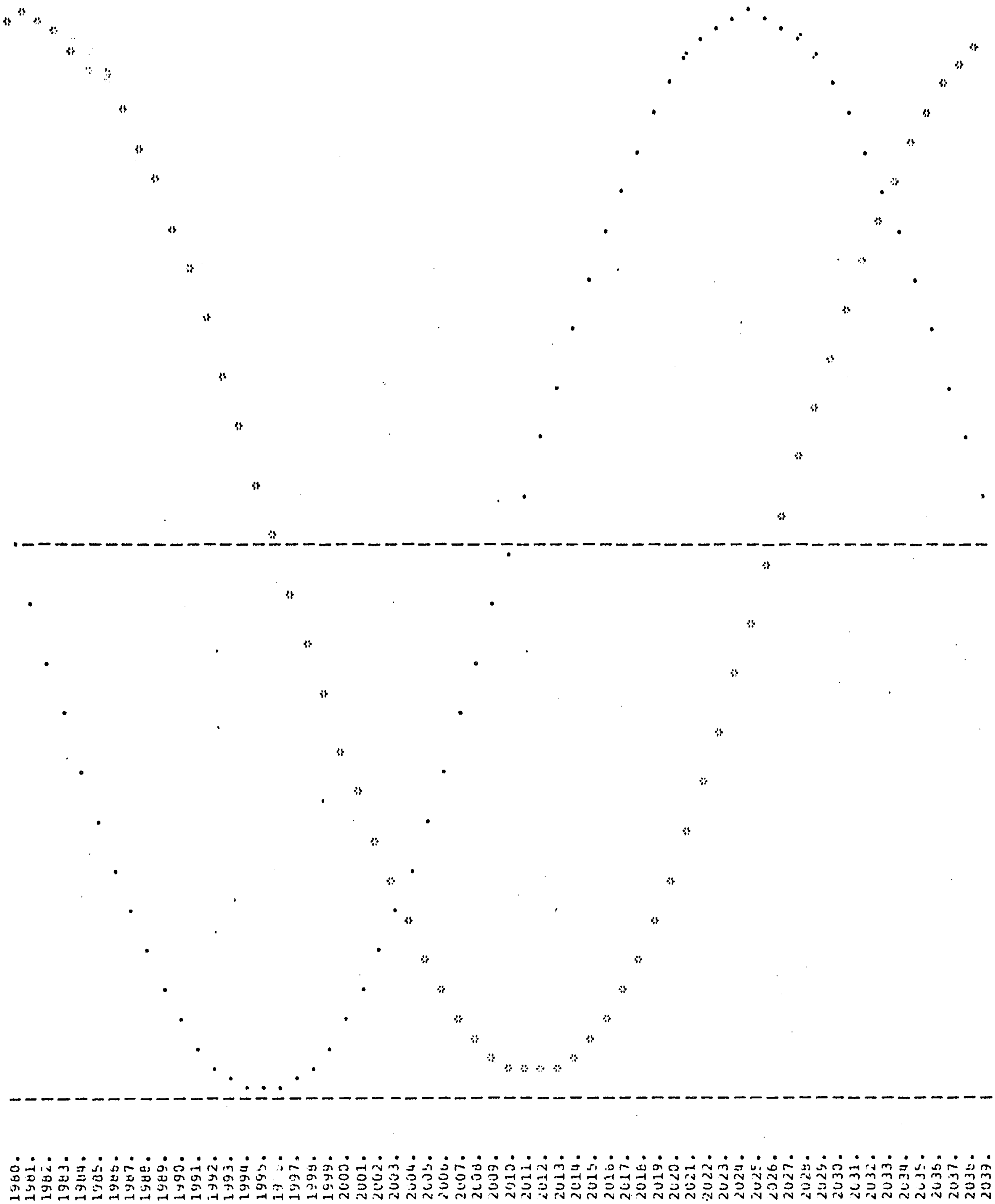

```
SIGTP=1

Is this an online session? (Y/N)
                                                N
TYPE OF CALL AVAILABLE:
1: M1->M2. rural mobile to rural mobile in same UHF beam
2: M1->M3. rural mobile to rural mobile in different UHF beam. in same S-band
3: M1->M4. rural mobile to rural mobile in different UHF beam. in different S-band
4: M1->FC1. rural mobile to fixed in same S-band beam
5: M1->FC2. rural mobile to fixed in different S-band beam
6: FC1->M1. fixed to rural mobile in same S-band beam
7: FC2->M1. fixed to rural mobile in different S-band beam
INPUT TYPE OF CALL TO BE SIMULATED:
                                      1
MODE OF CALL AVAILABLE:
1: M1->M2. hard wired transponder
2: M1->M2. direct switched transponder
3: M1->M2. indirect switched transponder
4: M1->G1->M2. double hop system
INPUT MODE OF CALL TO BE SIMULATED:
                                      1
FREQUENCY OF THE BASEBAND SIGNAL ( LESS THAN 3000 HZ. ) (IN HERTZ. F7.2):
                                                                   1000.00 HZ
NOTE : POWER OF THE BASEBAND SIGNAL HAS TO BE LESS OR EQUAL THAN .5 WATTS:
       SO THAT THE MAXIMUM INSTANTANEOUS FREQUENCY DEVIATION IS
       LESS OR EQUAL THAN 12000 HZ
POWER OF THE BASEBAND SIGNAL(IN WATTS. F7.2):
                                                0.50 WATTS
THE CARRIER POWER (IN WATTS. F7.2):
                                        1.00 WATTS
THE FREQUENCY DEVIATION (IN HERTZ. F8.2): 12000 HZ.  (FIXED FOR NOW)
How many times the nyquist rate do you want the sampling frequency to be? (2 - 4. I1):
                                                                              2
THE CARRIER FREQUENCY (IN HERTZ. F7.2):(NOT USED FOR NOW)
DO YOU WANT THE COMPRESSOR/EXPANDER IN?  Y-YES , N-NO :
                                                      Y
DO YOU WANT THE PRE-EMPHASIS - DE-EMPHASIS FILTERS IN ?  Y-YES , N-NO :
                                                                  Y
DO YOU WANT A CO-CHANNEL INTERFERER IN THE UPLINK? Y-YES,N-NO:
                                                           Y
Are multiple values of the carrier to interference power
ratio to be tested? (Y/N):
                       Y
Input the range of values to be tested (in DB):
Input the initial value (-99 -- +99.I3) :
                                            30DB
Input the increment value (01 -- 99.I3) :
                                          10DB
Input the final value (01 -- 99.I3) :
                                     40DB
Are multiple values of the interference phase values
to be tested? (Y/N):
                    Y
Input the range of values to be tested (in degrees):
Input the initial value (F6.2) :
                                     5.00 DEGREES
Input the increment value (F6.2) :
                                     1.00 DEGREES
Input the final value (F6.2) :
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                                         6.00 DEGREES
IS FADING PRESENT IN THE UPLINK   CHANNEL? Y-YES.N-NO:
                                                     Y
IS THE INTERFERENCE FADED? Y-YES.N-NO:
                                        Y
THE UPLINK FADING CHANNEL IS PRESENT
TYPES OF FADING CHANNELS AVAILABLE:
 1: NO SPECULAR COMPONENT (RALEIGH FADING)
 2: SPECULAR COMPONENT, SHORTEST PATH
 3: SPECULAR COMPONENT, MEAN PATH
 INPUT TYPE OF CHANNEL:
                      2
ENTER THE MULTIPATH SPREAD TIME (IN MICROSECONDS, F9.2):
                                                              500.00 MICROSECONDS
ENTER THE DOPPLER SPREAD BANDWIDTH (IN HERTZ, F7.2):
                                                   1.00 HZ
Are multiple values of the specular to multipath power
ratio to be tested? (Y/N):
                        Y
Input the range of values to be tested (in DB):
Input the initial value (-99 -- +99,I3):
                                           50DB
Input the incerment value (-99 -- +99,I2):
                                         10DB
Input the final value (01 -- 99,I2):
                                      60DB
DO YOU WANT A CO-CHANNEL INTERFERER IN THE DOWNLINK? Y-YES.N-NO:
                                                            Y
Are multiple values of the carrier to interference power
ratio to be tested? (Y/N):
                        Y
Input the range of values to be tested (in DB):
Input the initial value (-99 -- +99,I3) :
                                            10DB
Input the increment value (01 -- 99,I3) :
                                          10DB
Input the final value (01 -- 99,I3) :
                                      20DB
Are multiple values of the interference phase values
to be tested? (Y/N):
                    Y
Input the range of values to be tested (in degrees):
Input the initial value (F6.2) :
                                   10.00DEGREES
Input the increment value (F6.2) :
                                    5.00DEGREES
Input the final value (F6.2) :
                                 15.00DEGREES
IS FADING PRESENT IN THE DOWNLINK CHANNEL? Y-YES.N-NO:
                                                     Y
IS A SPACE DIVERSITY RECEIVER BEING USED? Y-YES.N-NO:
                                                    Y
IS THE INTERFERENCE FADED? Y-YES.N-NO:
                                        Y
THE DOWNLINK FADING CHANNEL IS PRESENT
SET PARAMETERS FOR FIRST FADING CHANNEL:
TYPES OF FADING CHANNELS AVAILABLE:
 1: NO SPECULAR COMPONENT (RALEIGH FADING)
 2: SPECULAR COMPONENT, SHORTEST PATH
 3: SPECULAR COMPONENT, MEAN PATH
```

```
 INPUT TYPE OF CHANNEL:
                                 2
ENTER THE MULTIPATH SPREAD TIME (IN MICROSECONDS, F9.2):
                                                                 500.00 MICROSECONDS
ENTER THE DOPPLER SPREAD BANDWIDTH (IN HERTZ, F7.2):
                                                            1.00 HZ
Are multiple values of the specular to multipath power
ratio to be tested? (Y/N):
                                   Y
Input the range of values to be tested (in DB):
Input the initial value (-99 -- +99,I3):
                                                  11DB
Input the incerment value (-99 -- +99,I2):
                                               10DB
Input the final value (01 -- 99,I2):
                                            23DB
SET PARAMETERS FOR THE SECOND FADING CHANNEL:
TYPES OF FADING CHANNELS AVAILABLE:
 1: NO SPECULAR COMPONENT (RALEIGH FADING)
 2: SPECULAR COMPONENT, SHORTEST PATH
 3: SPECULAR COMPONENT, MEAN PATH
 INPUT TYPE OF CHANNEL:
                                 2
ENTER THE MULTIPATH SPREAD TIME (IN MICROSECONDS, F9.2):
                                                                 500.00 MICROSECONDS
ENTER THE DOPPLER SPREAD BANDWIDTH (IN HERTZ, F7.2):
                                                            1.00 HZ
Are multiple values of the specular to multipath power
ratio to be tested? (Y/N):
                                   Y
Input the range of values to be tested (in DB):
Input the initial value (-99 -- +99,I3):
                                                  11DB
Input the incerment value (-99 -- +99,I2):
                                               10DB
Input the final value (01 -- 99,I2):
                                            23DB
Are multiple SNR values to be tested? Y-yes,N-no:
                                                       Y
Input the range of SNR values to be tested (in Db):
Input the initial value of SNR (-99 -- +99, I3):
                                                      10 DB
Input the increment value (01 -- 99, I2):
                                                 4 DB
Input the ending value of SNR (-99 -- +99, I3):
                                                      40 DB
IS A SPACE DIVERSITY RECEIVER REQUIRED? (Y/N)
                                                  Y
INPUT DURATION BETWEEN DECISION TIMES FOR THE S.D. RECEIVER (F7.5, IN SECONDS)
                                                                            0.00020SEC.
Input the approximate duration of simulation in seconds (0.01 - 9.99, F4.2):
                                                                               0.01 SEC.
Type of performance measurement available:
  1. Compare recovered output signal to original input signal
  2. Measure output signal to noise ratio
Input type:
                         2
 1- Specular to multipath power ratio- Uplink Channel.
 2-Specular to multipath power ratio- Downlink Channel
 3-Carrier to interference power ratios- UHF Uplink Channel
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4-Phase values of interference- UHF UplinkChannel
5-Carrier to interference power ratios- UHF Downlink Channel
6-Phase values of interference- UHF Downlink Channel
7-Input SNR Value
8-Output SNR Value

1	2	3	4	5	6	7	8
50.00	11.00	30.00	5.00	10.00	10.00	10.0000000	30.3934021
50.00	11.00	30.00	5.00	10.00	10.00	14.0000000	47.3245239
50.00	11.00	30.00	5.00	10.00	10.00	18.0000000	50.2981110
50.00	11.00	30.00	5.00	10.00	10.00	22.0000000	51.2792206
50.00	11.00	30.00	5.00	10.00	10.00	26.0000000	54.7541809
50.00	11.00	30.00	5.00	10.00	10.00	30.0000000	52.6393585
50.00	11.00	30.00	5.00	10.00	10.00	34.0000000	56.1096954
50.00	11.00	30.00	5.00	10.00	10.00	38.0000000	56.5043640
50.00	11.00	30.00	5.00	10.00	15.00	10.0000000	44.7787476
50.00	11.00	30.00	5.00	10.00	15.00	14.0000000	48.3026123
50.00	11.00	30.00	5.00	10.00	15.00	18.0000000	49.7561340
50.00	11.00	30.00	5.00	10.00	15.00	22.0000000	50.7426758
50.00	11.00	30.00	5.00	10.00	15.00	26.0000000	56.9706879
50.00	11.00	30.00	5.00	10.00	15.00	30.0000000	56.2624512
50.00	11.00	30.00	5.00	10.00	15.00	34.0000000	56.36[illegible]682
50.00	11.00	30.00	5.00	10.00	15.00	38.0000000	53.2024231
50.00	11.00	30.00	5.00	20.00	10.00	10.0000000	43.4536896
50.00	11.00	30.00	5.00	20.00	10.00	14.0000000	45.6832581
50.00	11.00	30.00	5.00	20.00	10.00	18.0000000	49.5198517
50.00	11.00	30.00	5.00	20.00	10.00	22.0000000	51.9888763
50.00	11.00	30.00	5.00	20.00	10.00	26.0000000	52.6079559
50.00	11.00	30.00	5.00	20.00	10.00	30.0000000	54.6950989
50.00	11.00	30.00	5.00	20.00	10.00	34.0000000	53.6224518
50.00	11.00	30.00	5.00	20.00	10.00	38.0000000	56.5738373
50.00	11.00	30.00	5.00	20.00	15.00	10.0000000	44.2585754
50.00	11.00	30.00	5.00	20.00	15.00	14.0000000	47.7853851
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275.	50.00	11.00	40.00	5.00	20.00	15.00	10.0000000	44.5611572
276.	50.00	11.00	40.00	5.00	20.00	15.00	14.0000000	47.4875946
277.	50.00	11.00	40.00	5.00	20.00	15.00	18.0000000	52.7612762
278.	50.00	11.00	40.00	5.00	20.00	15.00	22.0000000	52.9886627
279.	50.00	11.00	40.00	5.00	20.00	15.00	26.0000000	54.1265869
280.	50.00	11.00	40.00	5.00	20.00	15.00	30.0000000	55.7081604
281.								

```
Is this an online session? (Y/N)
                                            N
TYPE OF CALL AVAILABLE:
1: M1->M2, rural mobile to rural mobile in same UHF beam
2: M1->M3, rural mobile to rural mobile in different UHF beam, in same S-band
3: M1->M4, rural mobile to rural mobile in different UHF beam, in different S-band
4: M1->FC1, rural mobile to fixed in same S-band beam
5: M1->FC2, rural mobile to fixed in different S-band beam
6: FC1->M1, fixed to rural mobile in same S-band beam
7: FC2->M1, fixed to rural mobile in different S-band beam
INPUT TYPE OF CALL TO BE SIMULATED:
                                   1
MODE OF CALL AVAILABLE:
1: M1->M2, hard wired transponder
2: M1->M2, direct switched transponder
3: M1->M2, indirect switched transponder
4: M1->G1->M2, double hop system
INPUT MODE OF CALL TO BE SIMULATED:
                                   2
TYPE OF SIGNAL SOURCES AVAILABLE:
1: Program generated single tone sinuosoid.
2: Sampled voice from tape source.
Choose type of signal to be used (I1) :
                                      1
FREQUENCY OF THE BASEBAND SIGNAL ( LESS THAN 3000 HZ. ) (IN HERTZ, F7.2):
                                                                1000.00 HZ
NOTE : POWER OF THE BASEBAND SIGNAL HAS TO BE LESS OR EQUAL THAN .5 WATTS;
       SO THAT THE MAXIMUM INSTANTANEOUS FREQUENCY DEVIATION IS
       LESS OR EQUAL THAN 12000 HZ
POWER OF THE BASEBAND SIGNAL(IN WATTS, F7.2):
                                                 0.50 WATTS
THE CARRIER POWER (IN WATTS, F7.2):
                                       1.00 WATTS
THE FREQUENCY DEVIATION (IN HERTZ, F8.2): 12000 HZ.  (FIXED FOR NOW)
How many times the nyquist rate do you want the sampling frequency to be? (2 - 4, I1):
                                                                          2
THE CARRIER FREQUENCY (IN HERTZ, F7.2):(NOT USED FOR NOW)
DO YOU WANT THE COMPRESSOR/EXPANDER IN?  Y-YES , N-NO :
                                                     Y
DO YOU WANT THE PRE-EMPHASIS - DE-EMPHASIS FILTERS IN ?  Y-YES , N-NO :
                                                                N
DO YOU WANT A CO-CHANNEL INTERFERER IN THE UPLINK? Y-YES,N-NO:
                                                          Y
Are multiple values of the carrier to interference power
ratio to be tested? (Y/N):
                         Y
Input the range of values to be tested (in DB):
Input the initial value (-99 -- +99,I3) :
                                           0DB
Input the increment value (01 -- 99,I3) :
                                         4DB
Input the final value (01 -- 99,I3) :
                                      20DB
Are multiple values of the interference phase values
to be tested? (Y/N):
                    N
INPUT PHASE OF INTERFERENCE IN DEGREES (F7.2):
                                                0.0  DEGREES
IS FADING PRESENT IN THE   UHF - UPLINK   CHANNEL? Y-YES,N-NO:
```

```
                                                           N
DO YOU WANT A CO-CHANNEL INTERFERER IN THE DOWNLINK? Y-YES,N-NO:
                                                                  N
IS FADING PRESENT IN THE   UHF - DOWNLINK CHANNEL? Y-YES,N-NO:
                                                           N
Are multiple SNR values to be tested? Y-yes,N-no:
                                                      Y
Input the range of SNR values to be tested (in Db):
Input the initial value of SNR (-99 -- +99, I3):
                                                      2 DB
Input the increment value (01 -- 99, I2):
                                              4 DB
Input the ending value of SNR (-99 -- +99, I3):
                                                     40 DB
IS A SPACE DIVERSITY RECEIVER REQUIRED? (Y/N)
                                                 N
Input the approximate duration of simulation in seconds (0.01 - 9.99, F5.2):
                                                                              0.11 SEC.
Type of performance measurement available:
  1. Compare recovered output signal to original input signal
  2. Measure output signal to noise ratio
Input type:
        2
Do you want output to be plotted ? (Y/N):
                                              Y

 1-Carrier to interference power ratios- UHF Uplink Channel
 2-Input SNR Value
 3-Output SNR Value
   1       2                  3
 ------  ------------      ------------
   0.0      2.0000000         1.0499640
   0.0      6.0000000         0.8951783
   0.0     10.0000000         0.5626253
   0.0     14.0000000         0.3405598
   0.0     18.0000000         0.2657211
   0.0     22.0000000         0.2262439
   0.0     26.0000000         0.2255912
   0.0     30.0000000         0.2257367
   0.0     34.0000000         0.2257131
   0.0     38.0000000         0.2256934
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    |09876543210987654321098765432109876543210987654321098765432101234567890123456789012345678901234567890123456789012345
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120.      19|                                                  |
121.      18|                                                  |
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124.      15|                                                  |
125.      14|                                                  |
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132.       7|                                                  |
133.       6|                                                  |
134.       5|                                                  |
135.       4|                                                  |
136.       3|                                                  |
137.       2|                                                  |
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140.       -|                                                  |
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142.      -3|                                                  |
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166.      56|                                                  |
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171.      51|                                                  |
172.      50|                                                  |
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212.      10|
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214.       8|
215.       7|
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217.       5|
218.       4|
219.       3|
220.       2|
221.       1|
222.       0|
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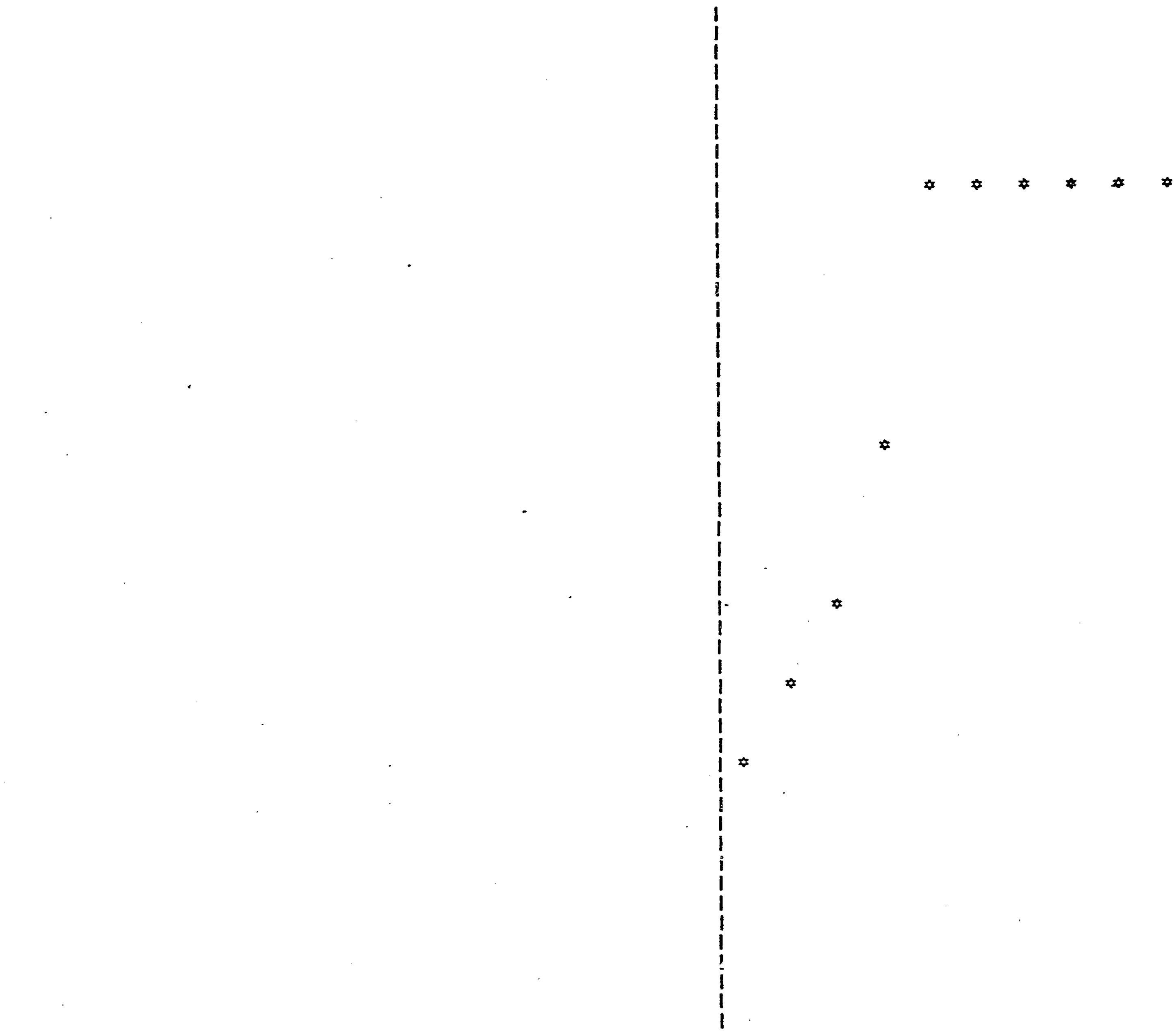

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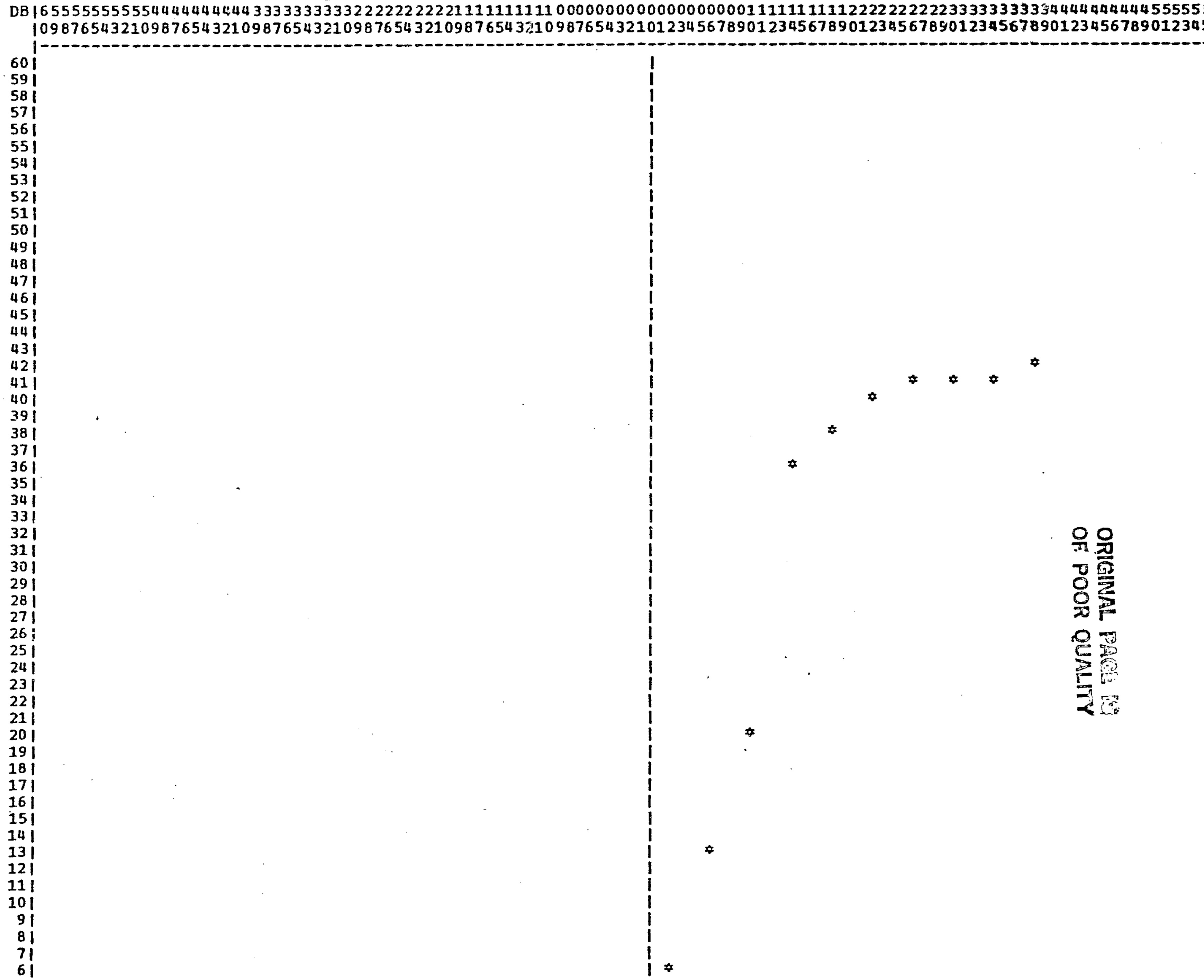

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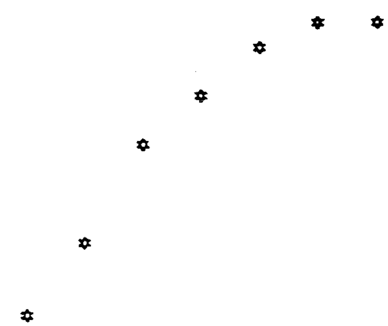

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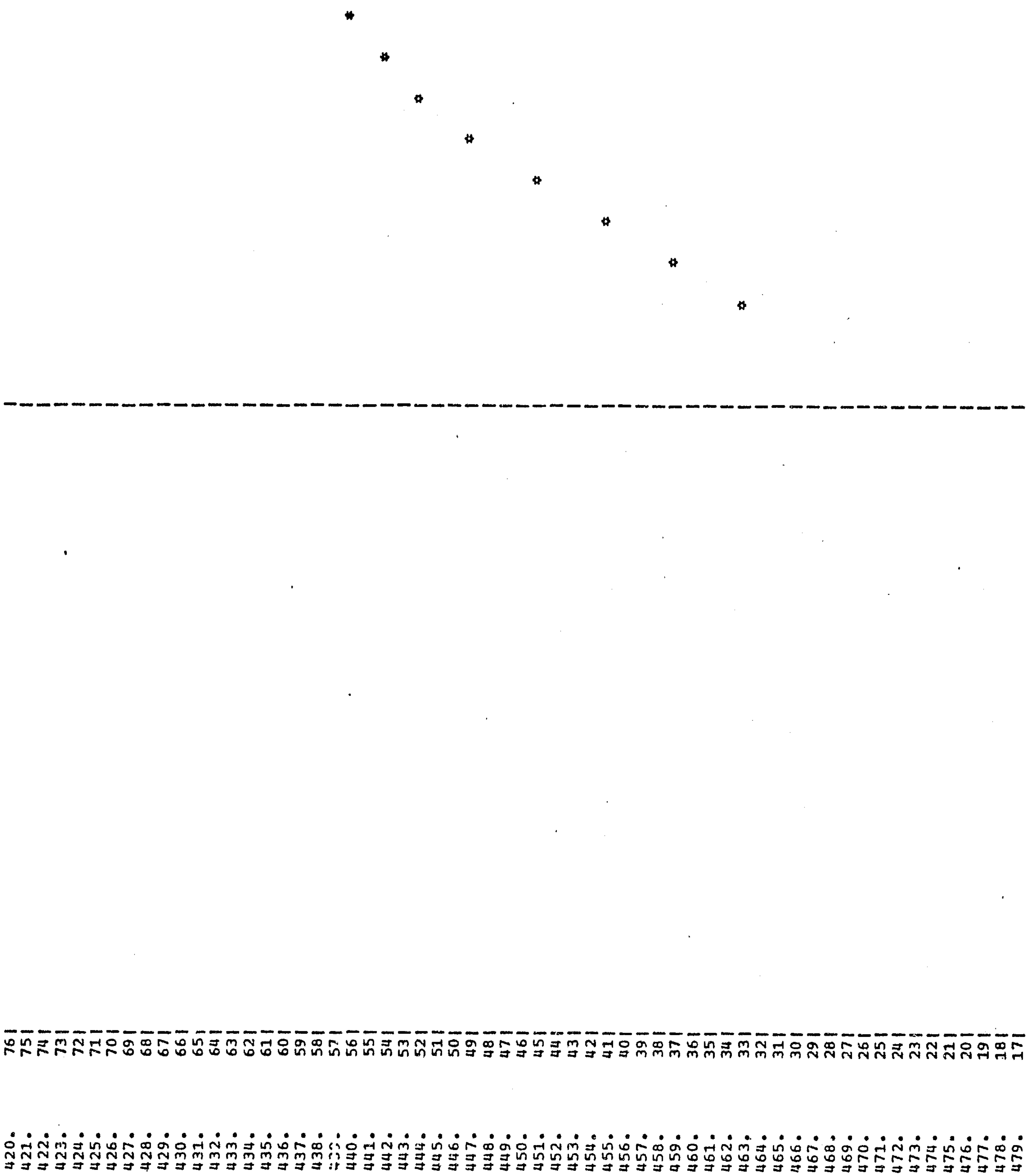
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    20.00    14.0000000         37.2620392
    20.00    18.0000000         41.1725922
    20.00    22.0000000         45.0943604
    20.00    26.0000000         49.0807800
    20.00    30.0000000         53.0763855
    20.00    34.0000000         56.6542053
    20.00    38.0000000         59.9796906
       DB|655555555554444444444333333333322222222221111111111000000000000000000001111111111222222222233333333334444444444555555
         |0987654321098765432109876543210987654321098765432101234567890123456789012345678901234567890123456789012345
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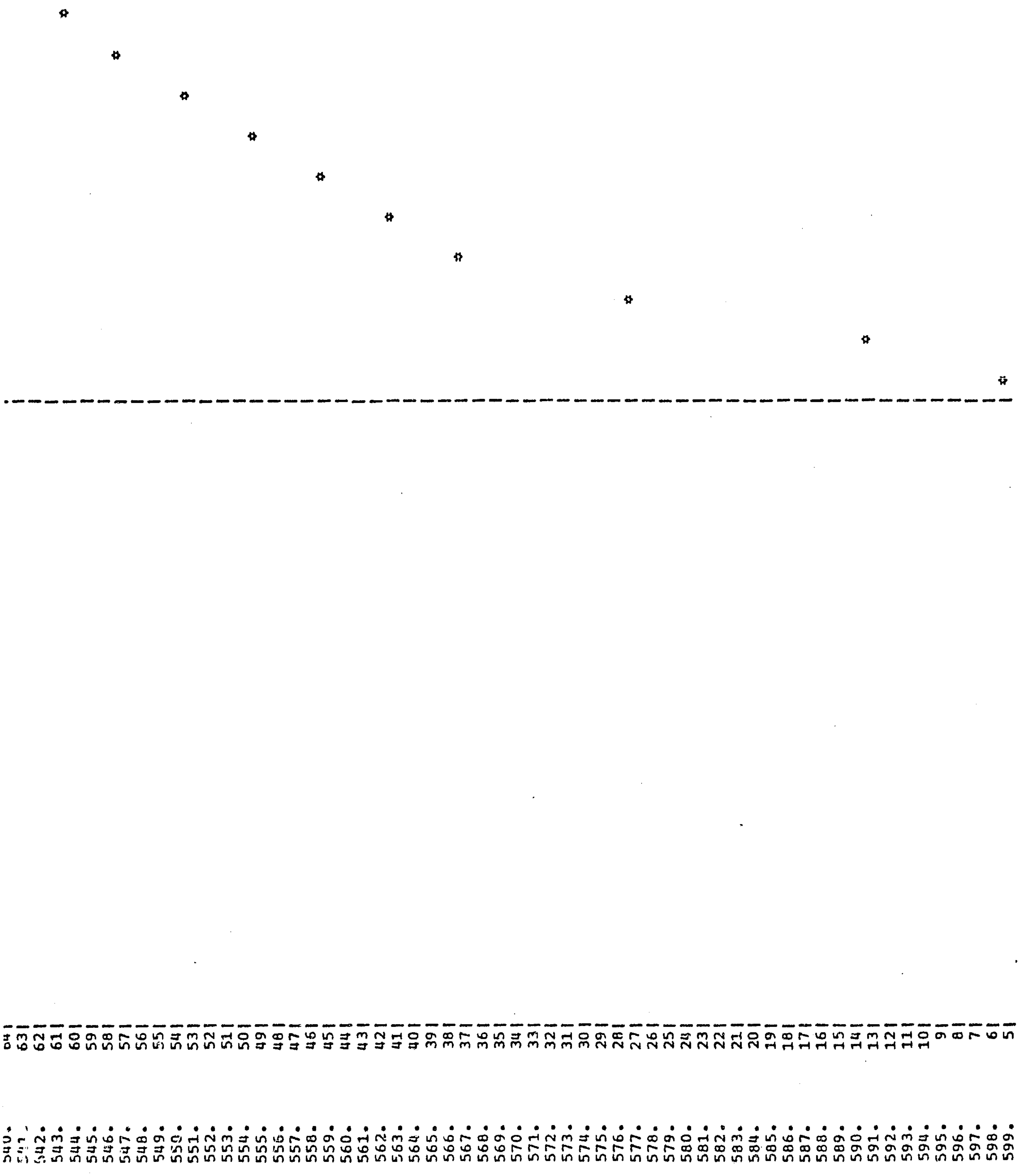
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599. 5

```
Is this an online session? (Y/N)
                                                N
TYPE OF CALL AVAILABLE:
1: M1->M2, rural mobile to rural mobile in same UHF beam
2: M1->M3, rural mobile to rural mobile in different UHF beam, in same S-band
3: M1->M4, rural mobile to rural mobile in different UHF beam, in different S-band
4: M1->FC1, rural mobile to fixed in same S-band beam
5: M1->FC2, rural mobile to fixed in different S-band beam
6: FC1->M1, fixed to rural mobile in same S-band beam
7: FC2->M1, fixed to rural mobile in different S-band beam
INPUT TYPE OF CALL TO BE SIMULATED:
                                       1
MODE OF CALL AVAILABLE:
1: M1->M2, hard wired transponder
2: M1->M2, direct switched transponder
3: M1->M2, indirect switched transponder
4: M1->G1->M2, double hop system
INPUT MODE OF CALL TO BE SIMULATED:
                                       4
TYPE OF SIGNAL SOURCES AVAILABLE:
1: Program generated single tone sinuosoid.
2: Sampled voice from tape source.
Choose type of signal to be used (I1) :
                                          1
FREQUENCY OF THE BASEBAND SIGNAL ( LESS THAN 3000 HZ. ) (IN HERTZ, F7.2):
                                                                          1000.00 HZ
NOTE : POWER OF THE BASEBAND SIGNAL HAS TO BE LESS OR EQUAL THAN .5 WATTS;
       SO THAT THE MAXIMUM INSTANTANEOUS FREQUENCY DEVIATION IS
       LESS OR EQUAL THAN 12000 HZ
POWER OF THE BASEBAND SIGNAL(IN WATTS, F7.2):
                                                 0.50 WATTS
THE CARRIER POWER (IN WATTS, F7.2):
                                         1.00 WATTS
THE FREQUENCY DEVIATION (IN HERTZ, F8.2): 12000 HZ.  (FIXED FOR NOW)
How many times the nyquist rate do you want the sampling frequency to be? (2 - 4, I1):
                                                                                      2
THE CARRIER FREQUENCY (IN HERTZ, F7.2):(NOT USED FOR NOW)
DO YOU WANT THE COMPRESSOR/EXPANDER IN?  Y-YES , N-NO :
                                                       Y
DO YOU WANT THE PRE-EMPHASIS - DE-EMPHASIS FILTERS IN ?  Y-YES , N-NO :
                                                                       N
DO YOU WANT A CO-CHANNEL INTERFERER IN THE UPLINK? Y-YES,N-NO:
                                                               N
IS FADING PRESENT IN THE   UHF - UPLINK   CHANNEL? Y-YES,N-NO:
                                                      Y
IS THE INTERFERENCE FADED? Y-YES,N-NO:
                                          N
THE UPLINK FADING CHANNEL IS PRESENT
TYPES OF FADING CHANNELS AVAILABLE:
 1: NO SPECULAR COMPONENT (RALEIGH FADING)
 2: SPECULAR COMPONENT, SHORTEST PATH
 3: SPECULAR COMPONENT, MEAN PATH
 INPUT TYPE OF CHANNEL:
                      2
ENTER THE MULTIPATH SPREAD TIME (IN MICROSECONDS, F9.2):
                                                            500.00 MICROSECONDS
ENTER THE DOPPLER SPREAD BANDWIDTH (IN HERTZ, F7.2):
                                                        1.00 HZ
Are multiple values of the specular to multipath power
```

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ratio to be tested? (Y/N):
                                   Y
Input the range of values to be tested (in DB):
Input the initial value (-99 -- +99,I3):
                                             10DB
Input the incerment value (-99 -- +99,I2):
                                          25DB
Input the final value (01 -- 99,I2):
                                        90DB
DO YOU WANT A CO-CHANNEL INTERFERER IN THE S-BAND DOWNLINK ? Y-YES,N-NO:
                                                                   N
IS FADING PRESENT IN THE  S-BAND DOWNLINK CHANNEL? Y-YES,N-NO:
                                                       Y
IS A SPACE DIVERSITY RECEIVER BEING USED? Y-YES,N-NO:
                                                      N
THE DOWNLINK FADING CHANNEL IS PRESENT
SET PARAMETERS FOR FADING CHANNEL.
TYPES OF FADING CHANNELS AVAILABLE:
 1: NO SPECULAR COMPONENT (RALEIGH FADING)
 2: SPECULAR COMPONENT, SHORTEST PATH
 3: SPECULAR COMPONENT, MEAN PATH
 INPUT TYPE OF CHANNEL:
                            2
ENTER THE MULTIPATH SPREAD TIME (IN MICROSECONDS, F9.2):
                                                           500.00 MICROSECONDS
ENTER THE DOPPLER SPREAD BANDWIDTH (IN HERTZ, F7.2):
                                                       1.00 HZ
Are multiple values of the specular to multipath power
ratio to be tested? (Y/N):
                                   Y
Input the range of values to be tested (in DB):
Input the initial value (-99 -- +99,I3):
                                             11DB
Input the incerment value (-99 -- +99,I2):
                                          25DB
Input the final value (01 -- 99,I2):
                                        90DB
DO YOU WANT A CO-CHANNEL INTERFERER IN THE S-BAND UPLINK? Y-YES,N-NO:
                                                                  N
IS FADING PRESENT IN THE  S-BAND UPLINK   CHANNEL? Y-YES,N-NO:
                                                       Y
IS THE INTERFERENCE FADED? Y-YES,N-NO:
                                          N
THE UPLINK FADING CHANNEL IS PRESENT
TYPES OF FADING CHANNELS AVAILABLE:
 1: NO SPECULAR COMPONENT (RALEIGH FADING)
 2: SPECULAR COMPONENT, SHORTEST PATH
 3: SPECULAR COMPONENT, MEAN PATH
 INPUT TYPE OF CHANNEL:
                            2
ENTER THE MULTIPATH SPREAD TIME (IN MICROSECONDS, F9.2):
                                                           500.00 MICROSECONDS
ENTER THE DOPPLER SPREAD BANDWIDTH (IN HERTZ, F7.2):
                                                       1.00 HZ
Are multiple values of the specular to multipath power
ratio to be tested? (Y/N):
                                   Y
Input the range of values to be tested (in DB):
Input the initial value (-99 -- +99,I3):
                                             12DB
```

```
Input the incerment value (-99 -- +99,I2):
                                        25DB
Input the final value (01 -- 99,I2):
                                      90DB
DO YOU WANT A CO-CHANNEL INTFRFERER IN THE DOWNLINK? Y-YES,N-NO:
                                                              N
IS FADING PRESENT IN THE   UHF - DOWNLINK CHANNEL? Y-YES,N-NO:
                                                    Y
IS A SPACE DIVERSITY RECEIVER BEING USED? Y-YES,N-NO:
                                                     N
THE DOWNLINK FADING CHANNEL IS PRESENT
SET PARAMETERS FOR FADING CHANNEL.
TYPES OF FADING CHANNELS AVAILABLE:
 1: NO SPECULAR COMPONENT (RALEIGH FADING)
 2: SPECULAR COMPONENT, SHORTEST PATH
 3: SPECULAR COMPONENT, MEAN PATH
 INPUT TYPE OF CHANNEL:
                        2
ENTER THE MULTIPATH SPREAD TIME (IN MICROSECONDS, F9.2):
                                                         500.00 MICROSECONDS
ENTER THE DOPPLER SPREAD BANDWIDTH (IN HERTZ, F7.2):
                                                     1.00 HZ
Are multiple values of the specular to multipath power
ratio to be tested? (Y/N):
                          Y
Input the range of values to be tested (in DB):
Input the initial value (-99 -- +99,I3):
                                          14DB
Input the incerment value (-99 -- +99,I2):
                                        25DB
Input the final value (01 -- 99,I2):
                                      90DB
Are multiple SNR values to be tested? Y-yes,N-no:
                                                 Y
Input the range of SNR values to be tested (in Db):
Input the initial value of SNR (-99 -- +99, I3):
                                                1 DB
Input the increment value (01 -- 99, I2):
                                          5 DB
Input the ending value of SNR (-99 -- +99, I3):
                                               40 DB
IS A SPACE DIVERSITY RECEIVER REQUIRED? (Y/N)
                                             N
Input the approximate duration of simulation in seconds (0.01 - 9.99, F5.2):
                                                                            0.02 SEC.
Type of performance measurement available:
  1. Compare recovered output signal to original input signal
  2. Measure output signal to noise ratio
Input type:
           2
Do you want output to be plotted ? (Y/N):
                                         N

 1- Specular to multipath power ratio- UHF Uplink Channel.
 2-Specular to multipath power ratio- S-BANDDownlink Channel
 3- Specular to multipath power ratio- S-BANDUplink Channel.
 4-Specular to multipath power ratio- UHF DownlinkChannel
 5-Input SNR Value
 6-Output SNR Value
   1      2      3      4      5             6
```

END
DATE JUN 27 1983

180.						
181.	10.00	11.00	12.00	14.00	1.0000000	31.8197632
182.	10.00	11.00	12.00	14.00	6.0000000	34.6829987
183.	10.00	11.00	12.00	14.00	11.0000000	38.5540161
184.	10.00	11.00	12.00	14.00	16.0000000	40.3591614
185.	10.00	11.00	12.00	14.00	21.0000000	36.0269775
186.	10.00	11.00	12.00	14.00	26.0000000	40.2135925
187.	10.00	11.00	12.00	14.00	31.0000000	41.0075531
188.	10.00	11.00	12.00	14.00	36.0000000	41.8792419
189.	10.00	11.00	37.00	14.00	1.0000000	32.0381775
190.	10.00	11.00	37.00	14.00	6.0000000	38.1804352
191.	10.00	11.00	37.00	14.00	11.0000000	37.1580200
192.	10.00	11.00	37.00	14.00	16.0000000	42.1793671
193.	10.00	11.00	37.00	14.00	21.0000000	43.2643585
194.	10.00	11.00	37.00	14.00	26.0000000	46.9673157
195.	10.00	11.00	37.00	14.00	31.0000000	48.9451447
196.	10.00	11.00	37.00	14.00	36.0000000	42.9842072
197.	10.00	11.00	62.00	14.00	1.0000000	33.0088196
198.	10.00	11.00	62.00	14.00	6.0000000	37.2350464
199.	10.00	11.00	62.00	14.00	11.0000000	41.6312103
200.	10.00	11.00	62.00	14.00	16.0000000	42.7033081
201.	10.00	11.00	62.00	14.00	21.0000000	39.6892242
202.	10.00	11.00	62.00	14.00	26.0000000	39.7191010
203.	10.00	11.00	62.00	14.00	31.0000000	44.9123077
204.	10.00	11.00	62.00	14.00	36.0000000	39.7061920
205.	10.00	11.00	87.00	14.00	1.0000000	20.8714905
206.	10.00	11.00	87.00	14.00	6.0000000	36.3129120
207.	10.00	11.00	87.00	14.00	11.0000000	40.2752686
208.	10.00	11.00	87.00	14.00	16.0000000	42.8176880
209.	10.00	11.00	87.00	14.00	21.0000000	40.7845306
210.	10.00	11.00	87.00	14.00	26.0000000	45.0499725
211.	10.00	11.00	87.00	14.00	31.0000000	40.1223450
212.	10.00	11.00	87.00	14.00	36.0000000	45.1003876
213.	10.00	36.00	12.00	14.00	1.0000000	32.4762726
214.	10.00	36.00	12.00	14.00	6.0000000	34.8208313
215.	10.00	36.00	12.00	14.00	11.0000000	37.4087982
216.	10.00	36.00	12.00	14.00	16.0000000	42.6144714
217.	10.00	36.00	12.00	14.00	21.0000000	38.4624634
218.	10.00	36.00	12.00	14.00	26.0000000	43.3883820
219.	10.00	36.00	12.00	14.00	31.0000000	40.4772797
220.	10.00	36.00	12.00	14.00	36.0000000	43.5606537
221.	10.00	36.00	37.00	14.00	1.0000000	33.0967865
222.	10.00	36.00	37.00	14.00	6.0000000	37.3872528
223.	10.00	36.00	37.00	14.00	11.0000000	38.3372498
224.	10.00	36.00	37.00	14.00	16.0000000	40.9699707
225.	10.00	36.00	37.00	14.00	21.0000000	43.6113129
226.	10.00	36.00	37.00	14.00	26.0000000	45.5793457
227.	10.00	36.00	37.00	14.00	31.0000000	44.[illegible]579315
228.	10.00	36.00	37.00	14.00	36.0000000	43.0029449
229.	10.00	36.00	62.00	14.00	1.0000000	31.4471283
230.	10.00	36.00	62.00	14.00	6.0000000	35.7543030
231.	10.00	36.00	62.00	14.00	11.0000000	41.5781708
232.	10.00	36.00	62.00	14.00	16.0000000	43.9695587
233.	10.00	36.00	62.00	14.00	21.0000000	41.0463257
234.	10.00	36.00	62.00	14.00	26.0000000	43.2192688
235.	10.00	36.00	62.00	14.00	31.0000000	41.2209320
236.	10.00	36.00	62.00	14.00	36.0000000	42.5592041
237.	10.00	36.00	87.00	14.00	1.0000000	31.7581329
238.	10.00	36.00	87.00	14.00	6.0000000	36.1853180
239.	10.00	36.00	87.00	14.00	11.0000000	40.9545441